



US009433558B2

(12) **United States Patent**
Okuda et al.

(10) **Patent No.:** **US 9,433,558 B2**
(45) **Date of Patent:** **Sep. 6, 2016**

(54) **MEDICINE TRANSFUSION APPARATUS AND
MEDICINE TRANSFUSION METHOD**

(2015.05); *A61M 5/1782* (2013.01); *A61M 2209/045* (2013.01); *B65B 3/003* (2013.01)

(71) Applicant: **Panasonic Corporation**, Osaka (JP)

(58) **Field of Classification Search**

CPC *B65B 43/54-43/60*; *B65B 3/003*;
A61J 1/2096; *A61J 3/002*
USPC 141/27, 104, 144, 145, 148, 151, 241,
141/247, 329, 330
See application file for complete search history.

(72) Inventors: **Akinobu Okuda**, Nara (JP); **Tsuyoshi Tojo**, Osaka (JP); **Tohru Nakamura**, Osaka (JP)

(73) Assignee: **PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO., LTD.**, Osaka (JP)

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,645,171 A * 7/1953 Moreland *A23B 4/285*
141/172
2,656,785 A * 10/1953 Gannon *A23B 4/285*
141/329

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 303 days.

(Continued)

(21) Appl. No.: **14/360,100**

FOREIGN PATENT DOCUMENTS

(22) PCT Filed: **Mar. 25, 2013**

JP 1-244759 9/1989
JP 2007-319382 12/2007

(86) PCT No.: **PCT/JP2013/002012**

(Continued)

§ 371 (c)(1),

(2) Date: **May 22, 2014**

OTHER PUBLICATIONS

(87) PCT Pub. No.: **WO2013/157203**

International Search Report issued Jun. 18, 2013 in International (PCT) Application No. PCT/JP2013/002012.

PCT Pub. Date: **Oct. 24, 2013**

(Continued)

(65) **Prior Publication Data**

US 2014/0311621 A1 Oct. 23, 2014

Primary Examiner — Timothy L Maust

Assistant Examiner — Randall Gruby

(74) *Attorney, Agent, or Firm* — Wenderoth, Lind & Ponack, L.L.P.

(30) **Foreign Application Priority Data**

Apr. 18, 2012 (JP) 2012-094346

(57) **ABSTRACT**

(51) **Int. Cl.**

B67C 3/26 (2006.01)

A61J 1/20 (2006.01)

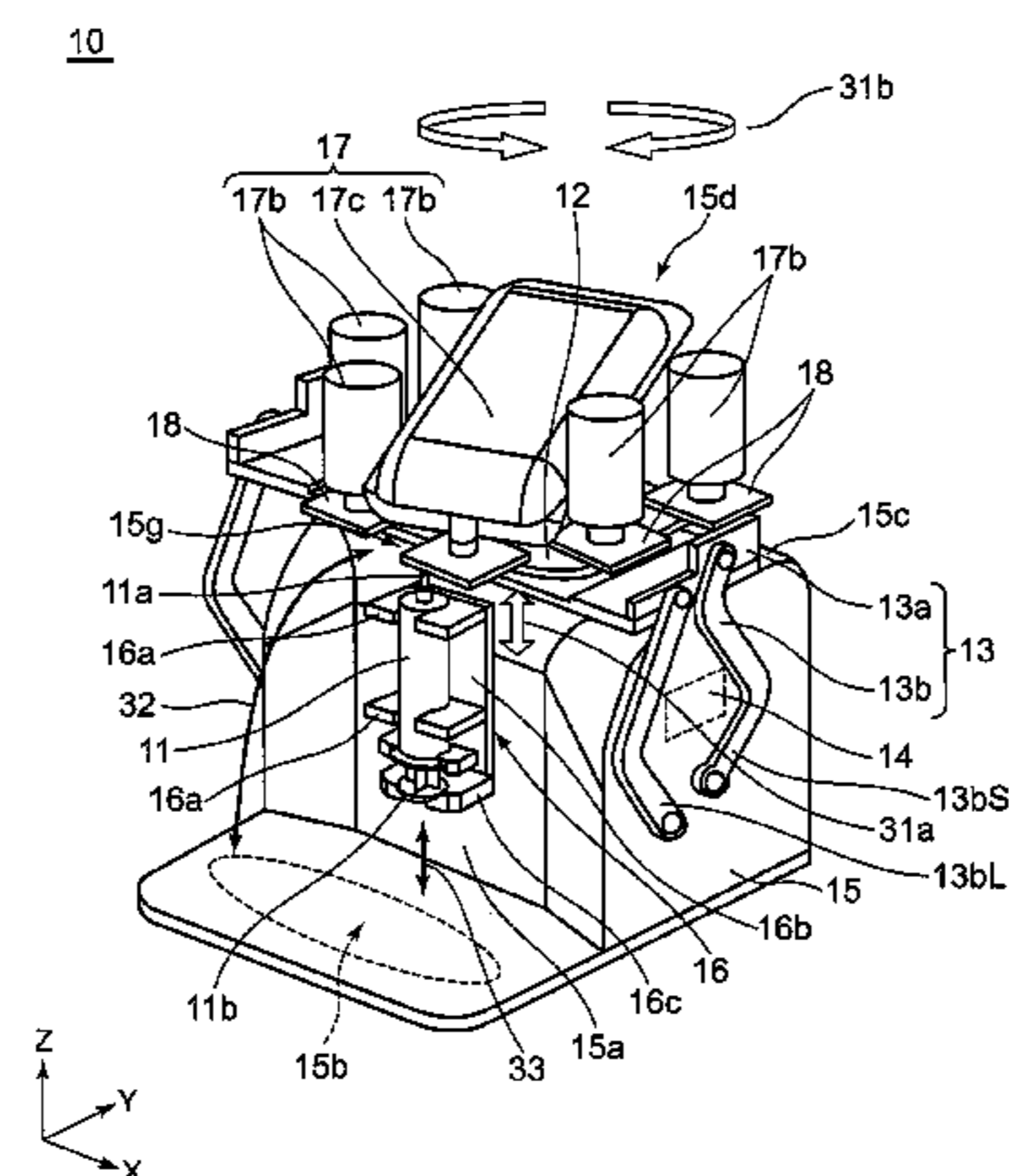
(Continued)

A medicine mixing apparatus transfusing a medicine using a syringe includes a medicine cassette holding a medicine container, a lifting unit moving the medicine cassette upward and downward to a middle position or a lower position of a main body while maintaining a horizontal attitude of the medicine cassette, a first holding portion held by the main body, and a second driving unit which drives a plunger of the syringe held by the first holding portion to transfuse the medicine.

(52) **U.S. Cl.**

CPC *A61J 1/2096* (2013.01); *A61J 3/002* (2013.01); *A61J 1/10* (2013.01); *A61J 1/201*

14 Claims, 23 Drawing Sheets



- (51) **Int. Cl.**
A61J 3/00 (2006.01)
A61J 1/10 (2006.01)
A61M 5/178 (2006.01)
B65B 3/00 (2006.01)

(56) **References Cited**
 U.S. PATENT DOCUMENTS

3,807,467 A * 4/1974 Tascher A61J 1/2096
 141/18
 3,863,556 A * 2/1975 Townsend A23B 4/28
 426/281
 4,142,000 A * 2/1979 Townsend A23B 4/285
 426/281
 4,467,708 A * 8/1984 Twiford A21C 15/007
 141/329
 4,924,771 A * 5/1990 Langen A23B 4/28
 99/533
 4,998,570 A * 3/1991 Strong A61M 5/1782
 128/DIG. 1
 5,881,640 A * 3/1999 R.ae butted.vsager .. A23B 4/28
 99/408
 6,360,794 B1 * 3/2002 Turner G01N 35/1079
 141/1
 6,761,191 B2 * 7/2004 Rosen B67C 3/001
 134/168 C
 8,191,339 B2 * 6/2012 Tribble A61J 3/002
 53/281
 8,211,082 B2 * 7/2012 Hasegawa A61J 1/2096
 604/411
 8,225,824 B2 * 7/2012 Eliuk B65B 3/003
 141/192

8,276,623 B2 * 10/2012 Van Vreeland B01F 11/0008
 141/104
 8,286,671 B1 * 10/2012 Strangis B65B 7/28
 141/104
 8,297,320 B2 * 10/2012 Giribona B65B 43/465
 141/2
 8,522,832 B2 * 9/2013 Lopez A61J 1/2096
 141/27
 D692,161 S * 10/2013 Okuda D24/220
 D695,906 S * 12/2013 Okuda D24/220
 8,596,309 B2 * 12/2013 Mizuno A61J 3/002
 141/104
 8,807,177 B2 * 8/2014 Strangis B63C 9/0005
 141/104
 2006/0049209 A1 * 3/2006 Baker A61J 1/2089
 222/252
 2008/0114328 A1 * 5/2008 Doherty A61J 1/2096
 604/414

FOREIGN PATENT DOCUMENTS

JP	2010-509002	3/2010
WO	2008/058280	5/2008
WO	2011/118835	9/2011

OTHER PUBLICATIONS

Notification Concerning Transmittal of International Preliminary Report on Patentability issued Oct. 30, 2014 in International (PCT) Application No. PCT/JP2013/002012.
 Notification of Transmittal of Translation of the International Preliminary Report on Patentability issued Oct. 30, 2014 in International (PCT) Application No. PCT/JP2013/002012.

* cited by examiner

Fig. 1

10

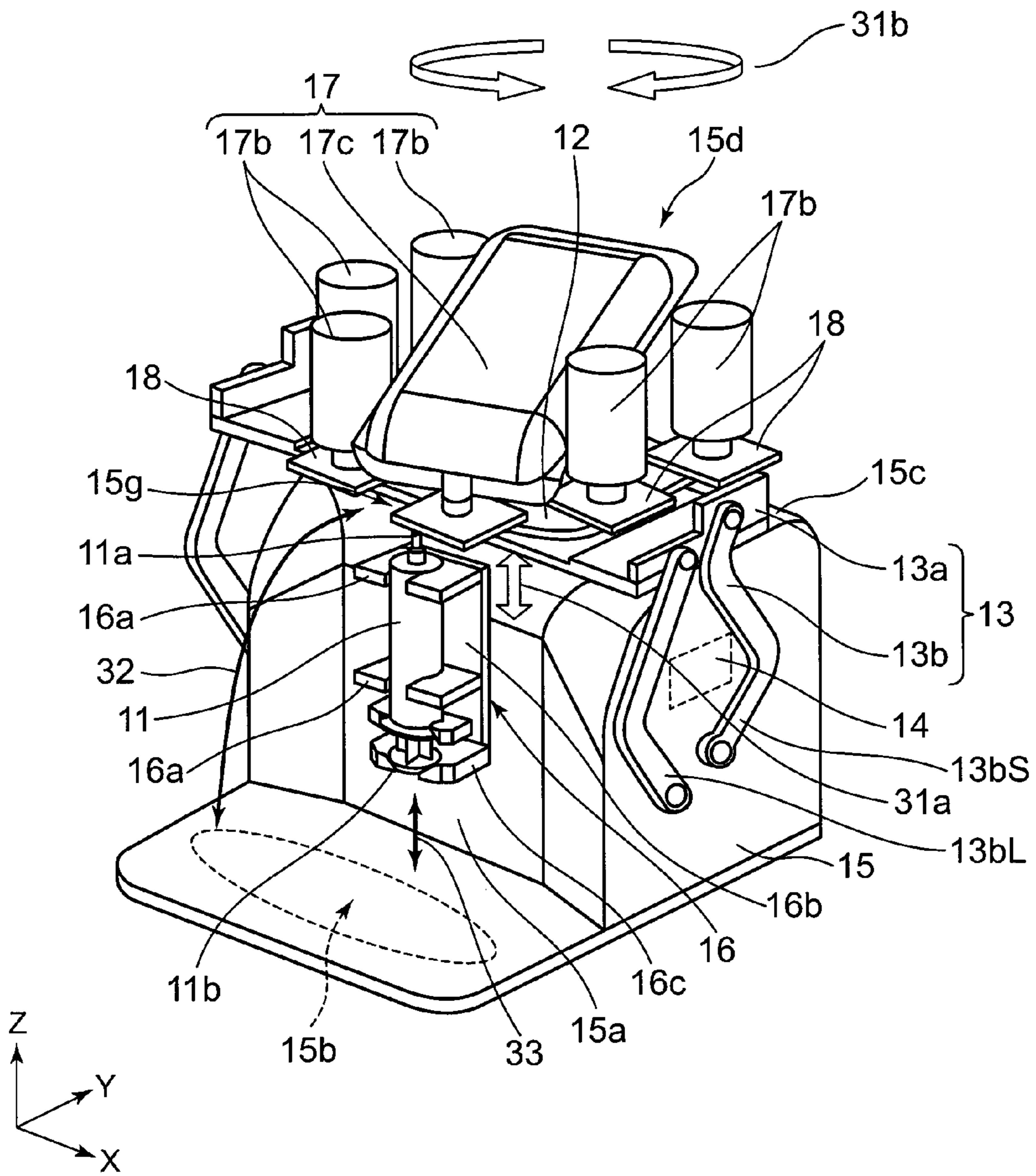


Fig. 2A

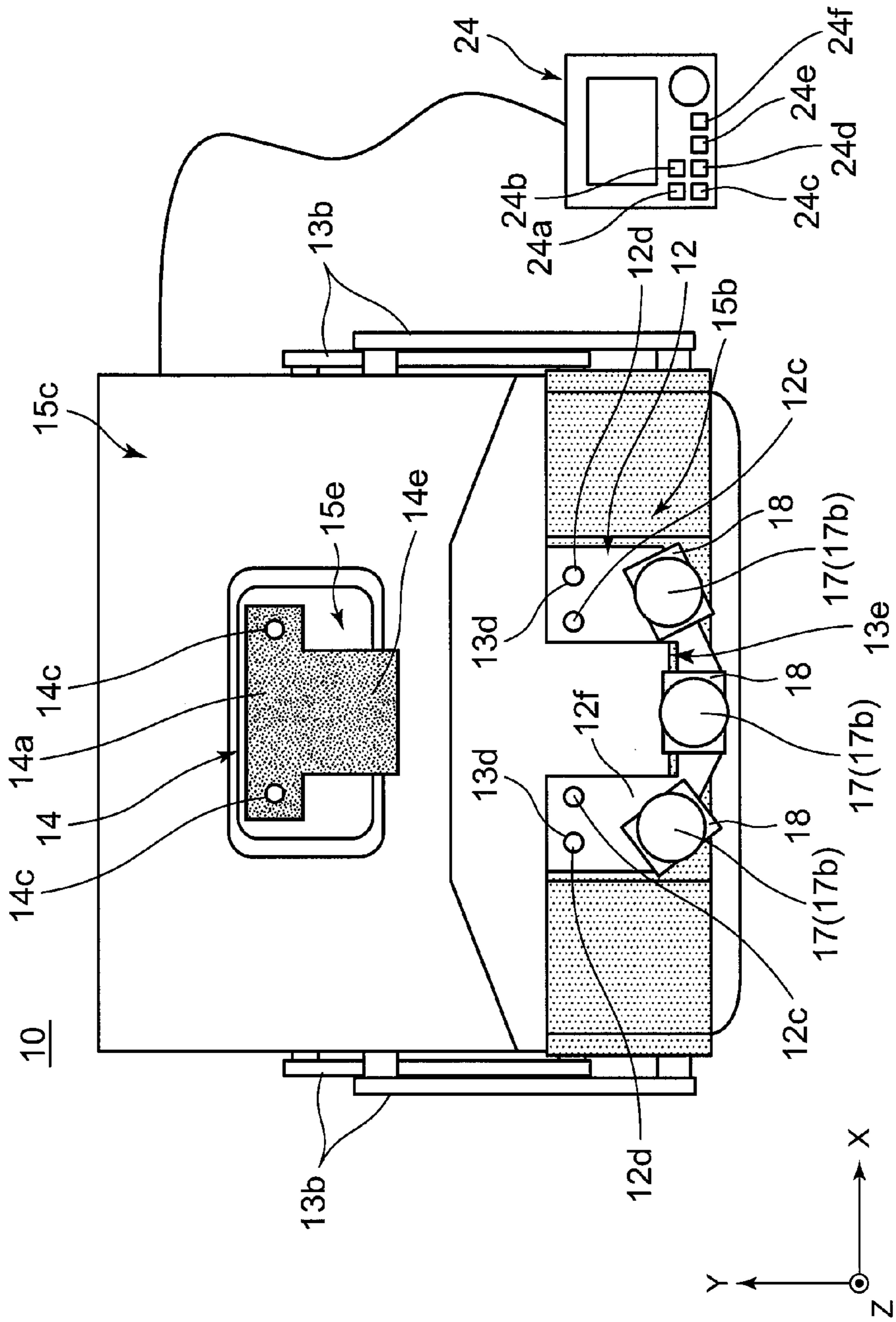


Fig. 2B

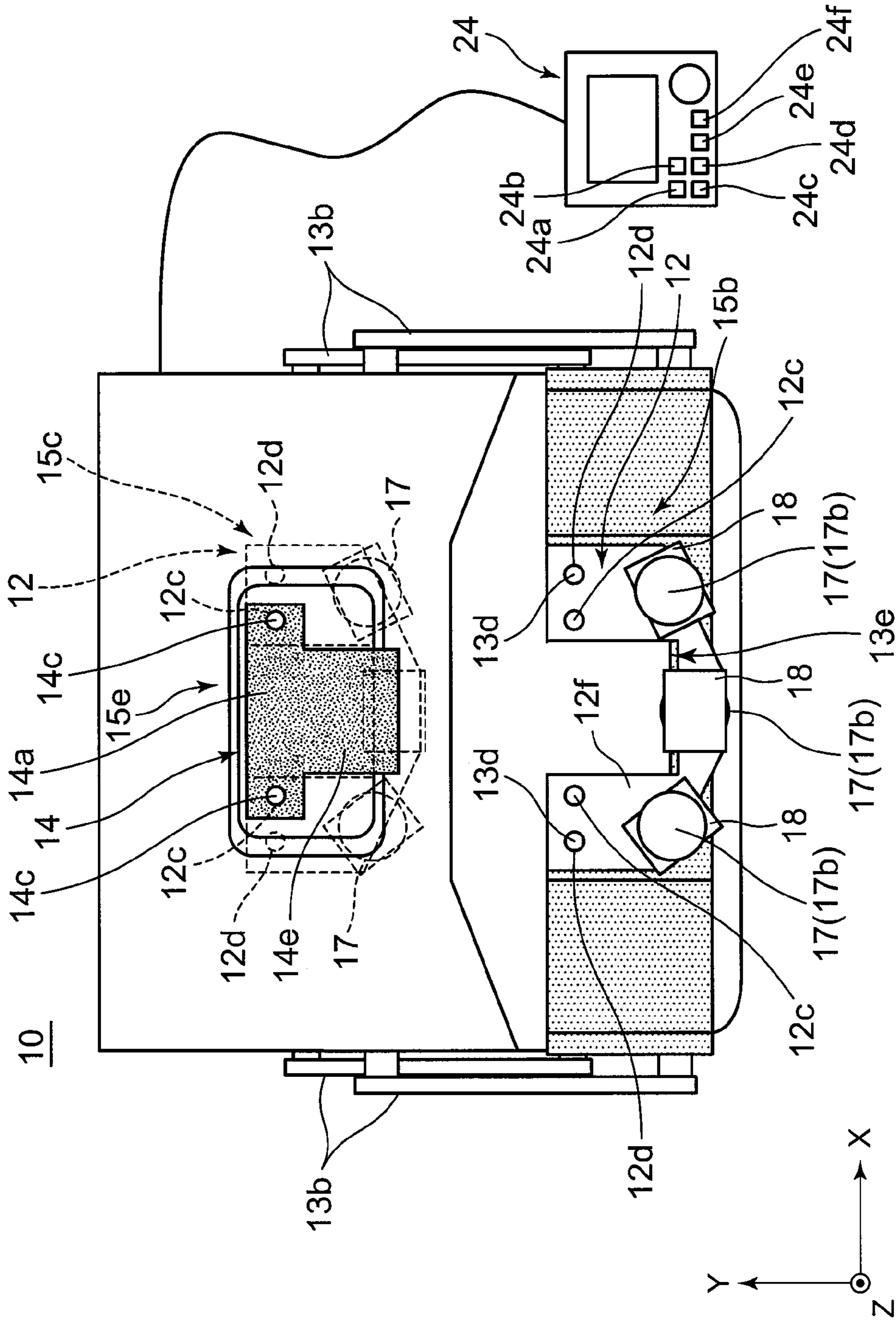


Fig.3

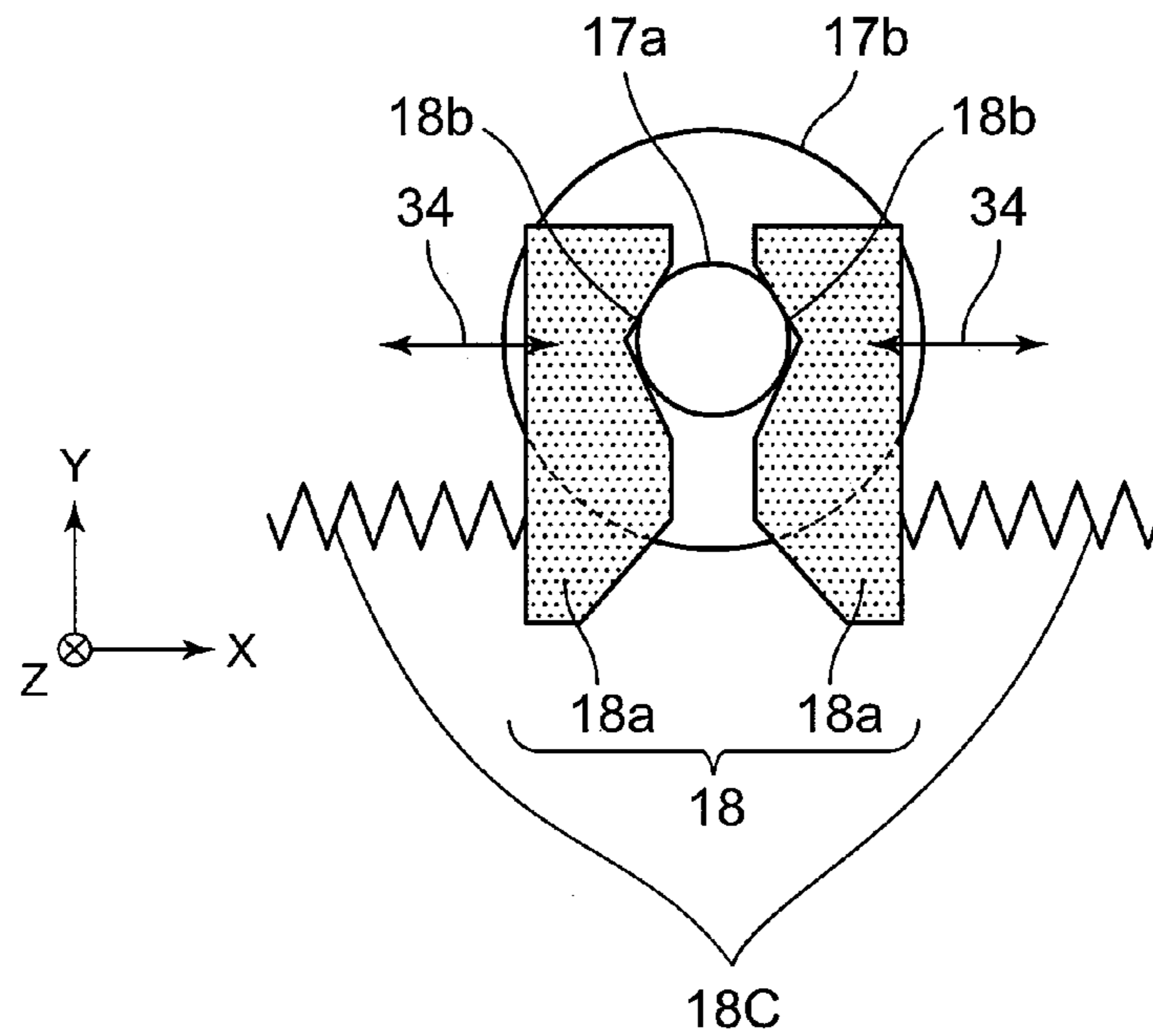


Fig.4

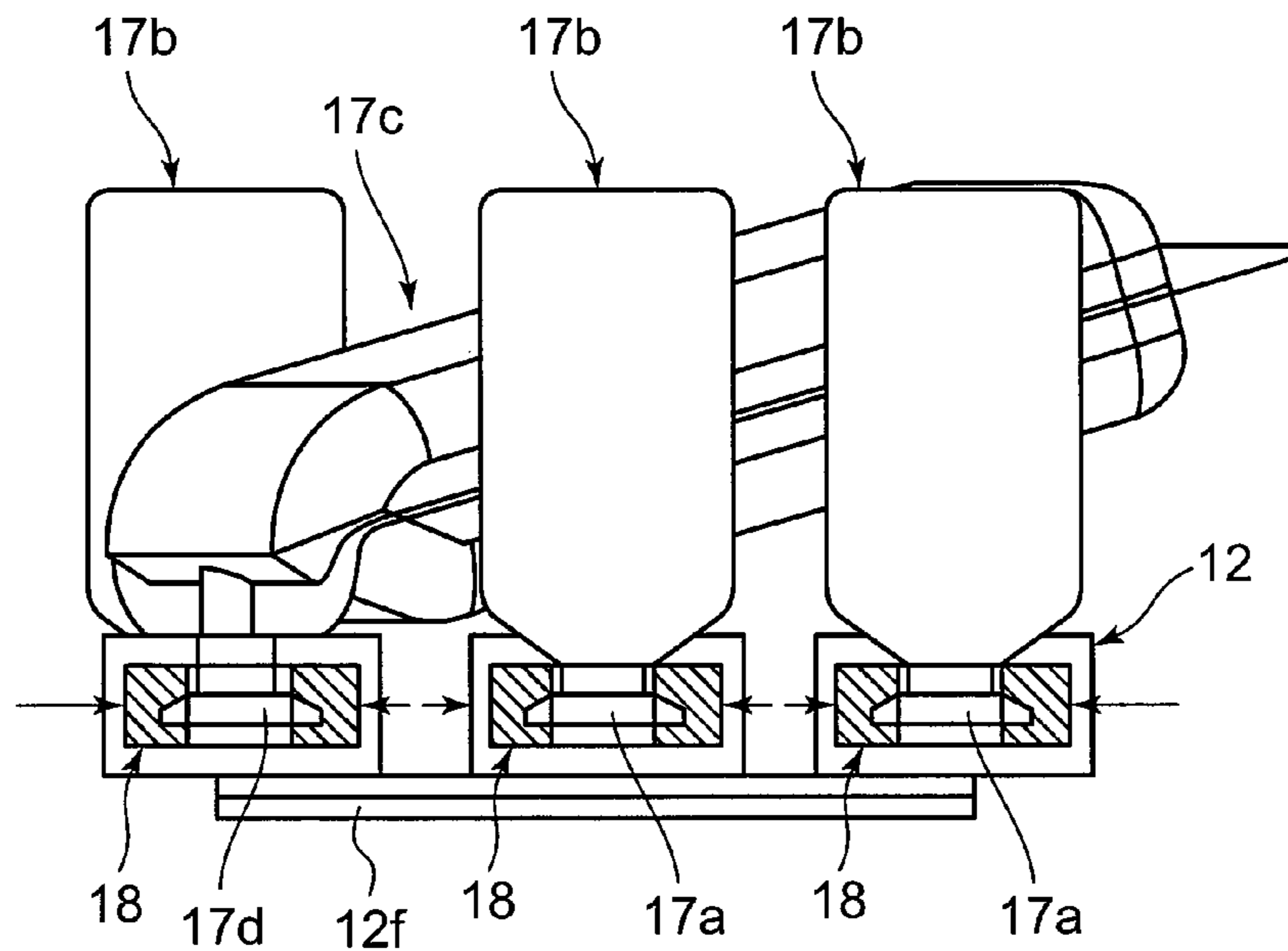


Fig. 5A

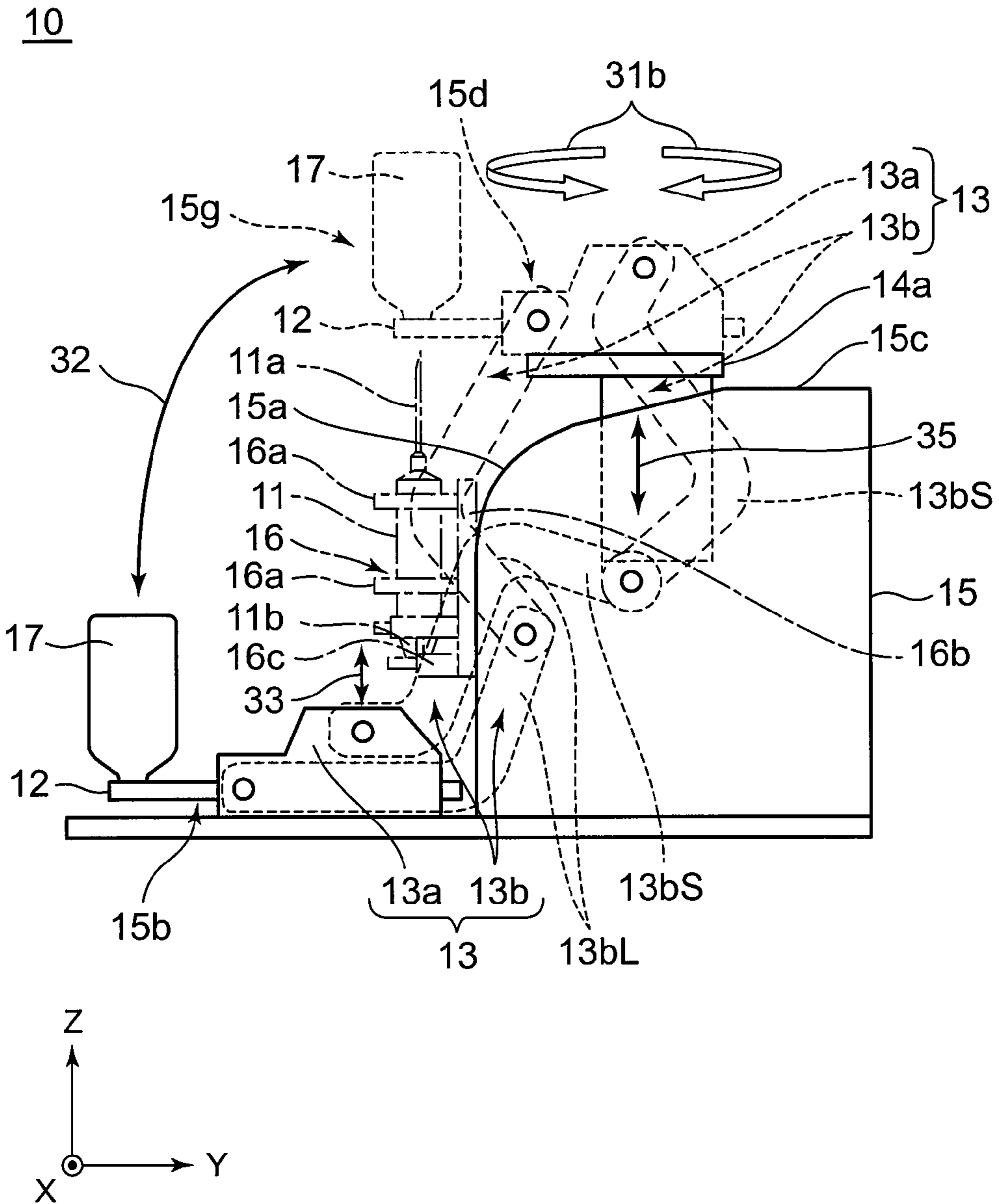


Fig. 5B

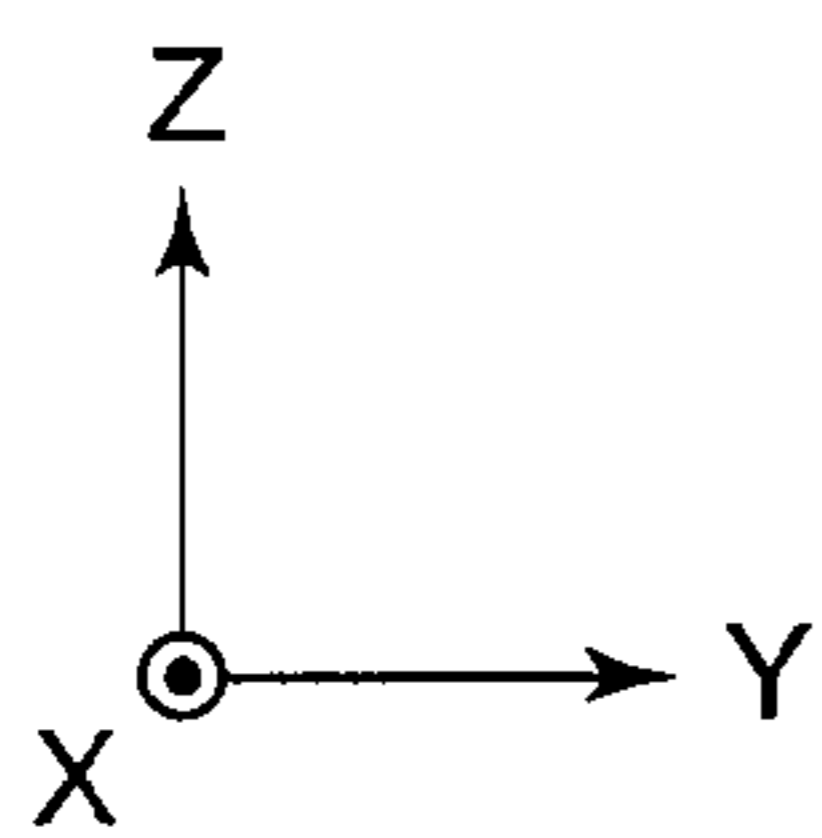
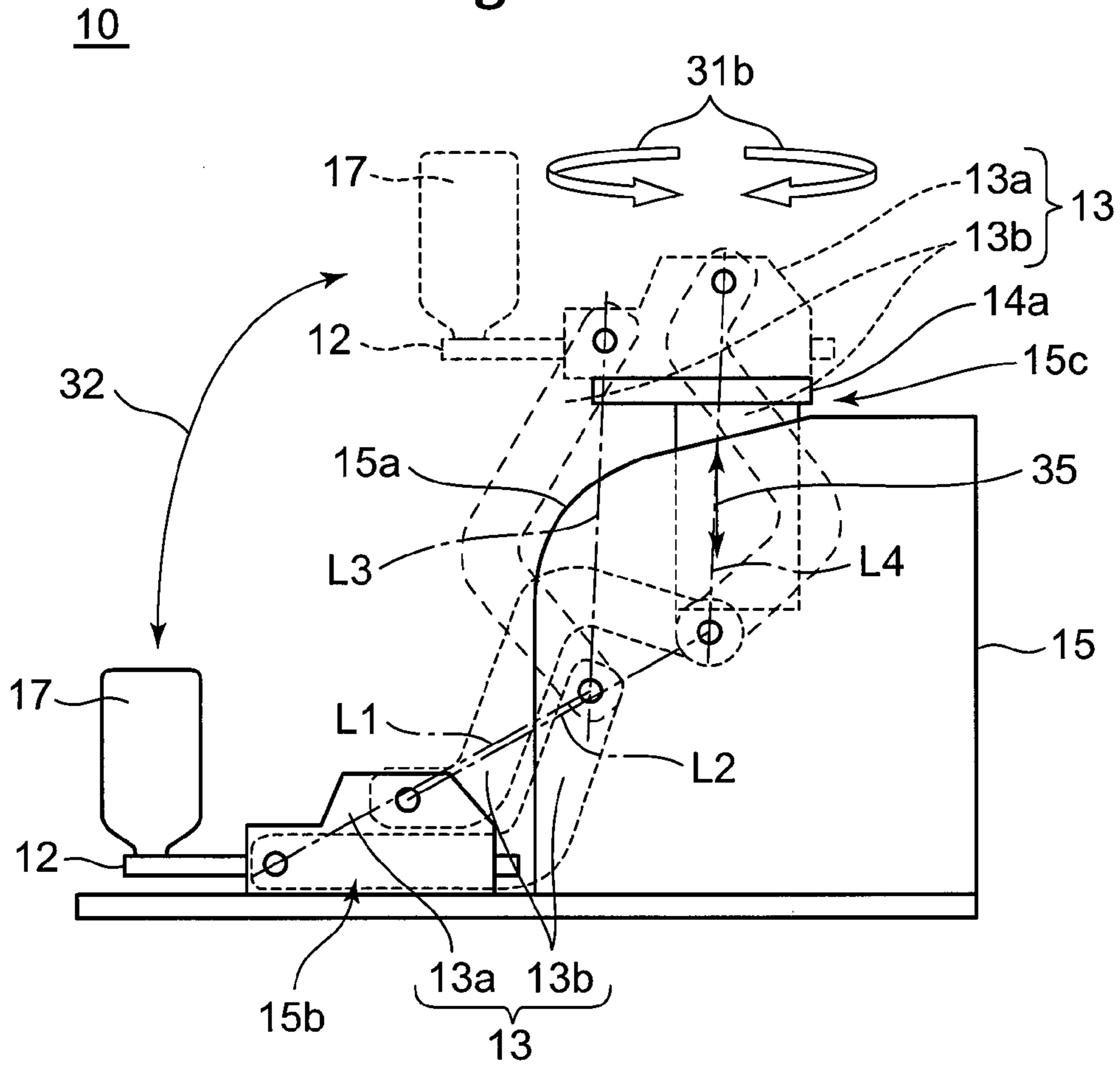


Fig. 6

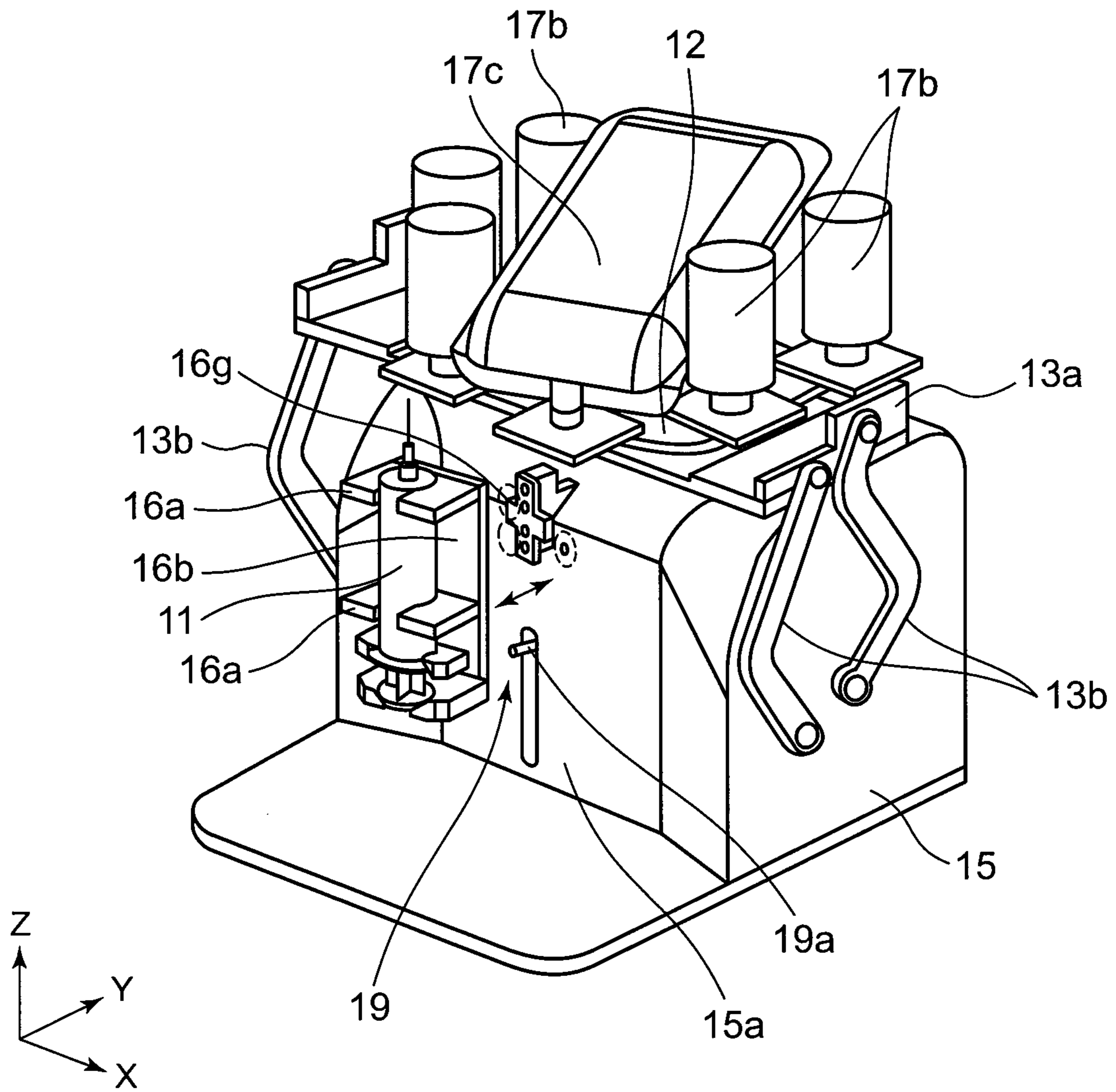


Fig. 7

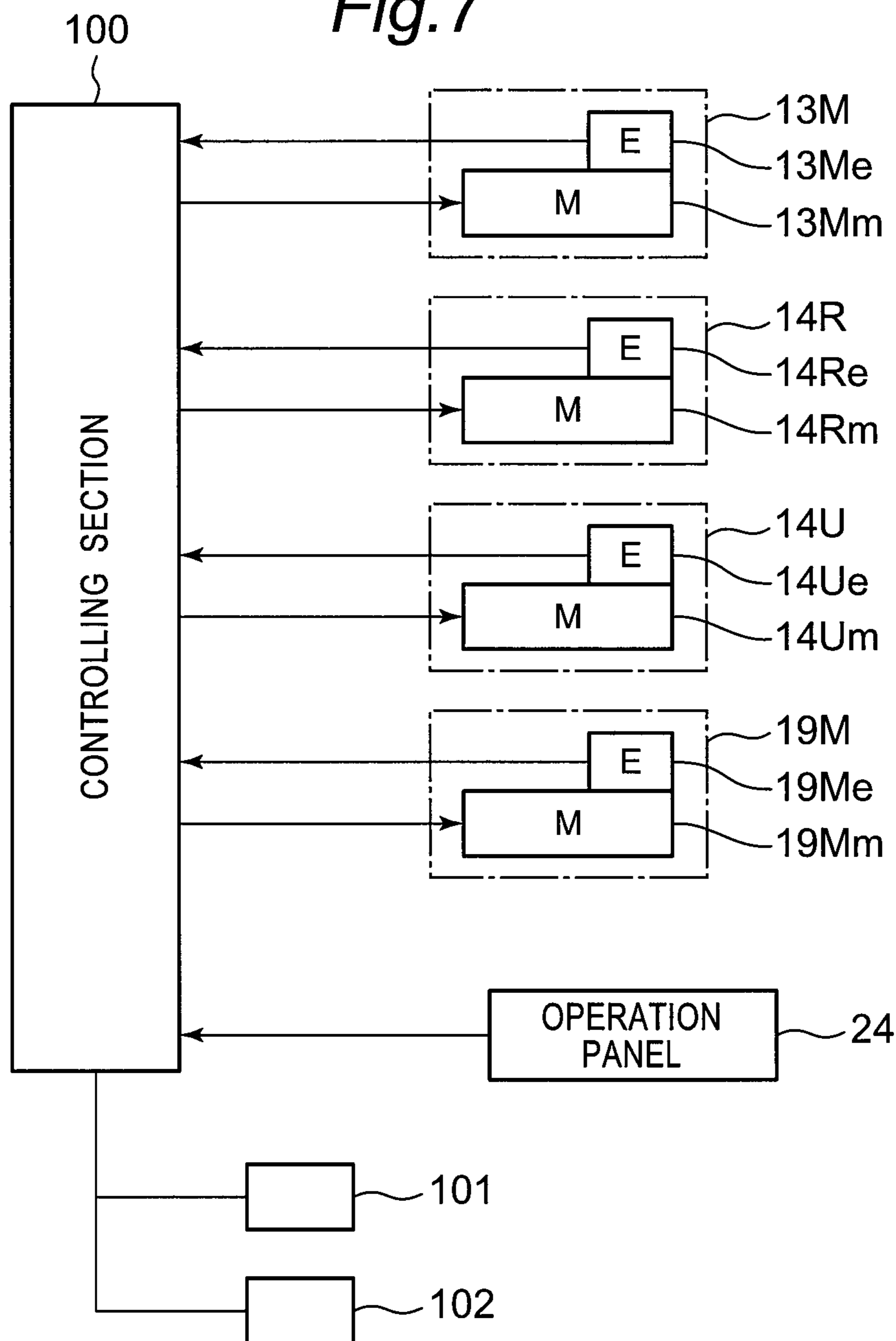


Fig. 8

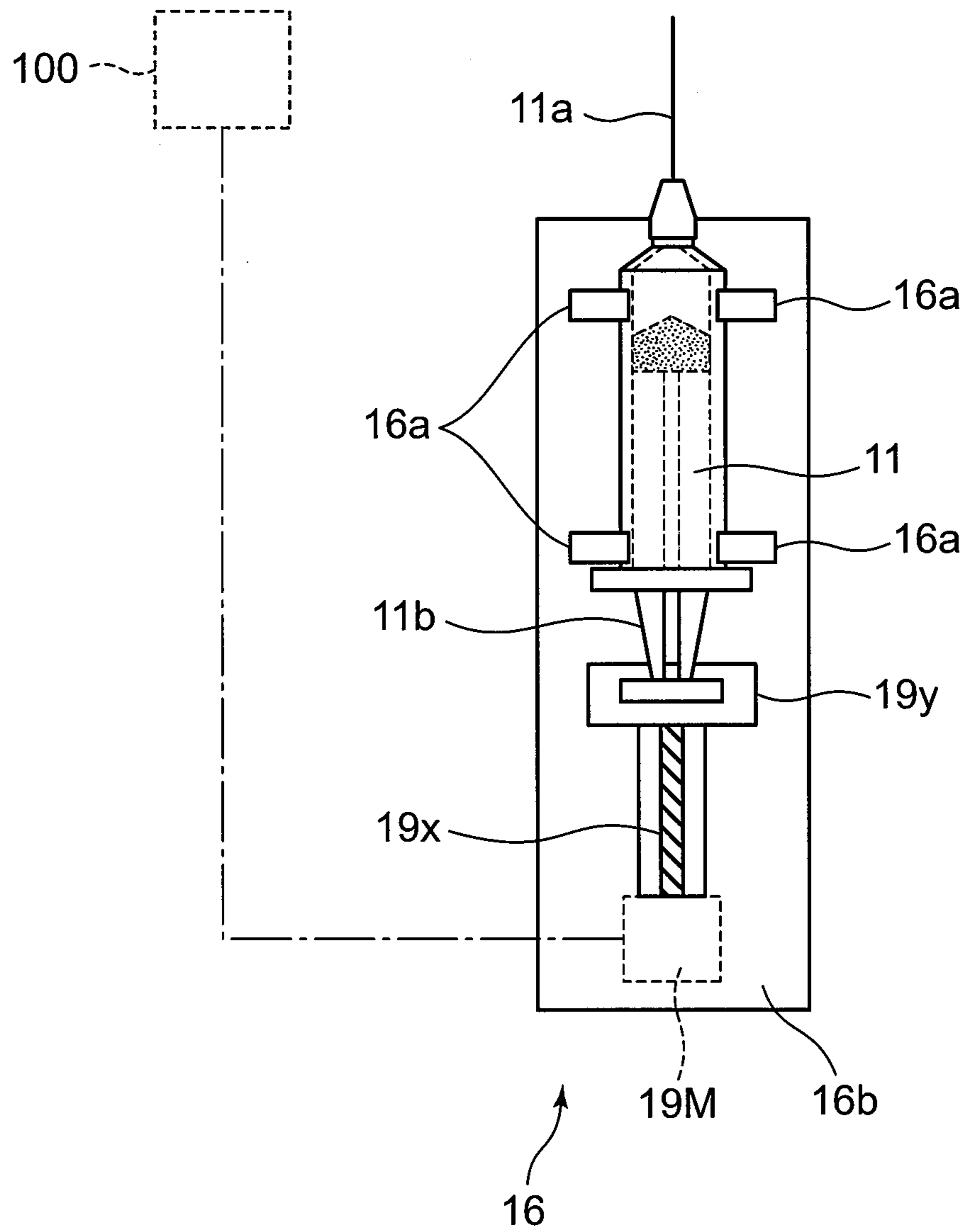


Fig.9

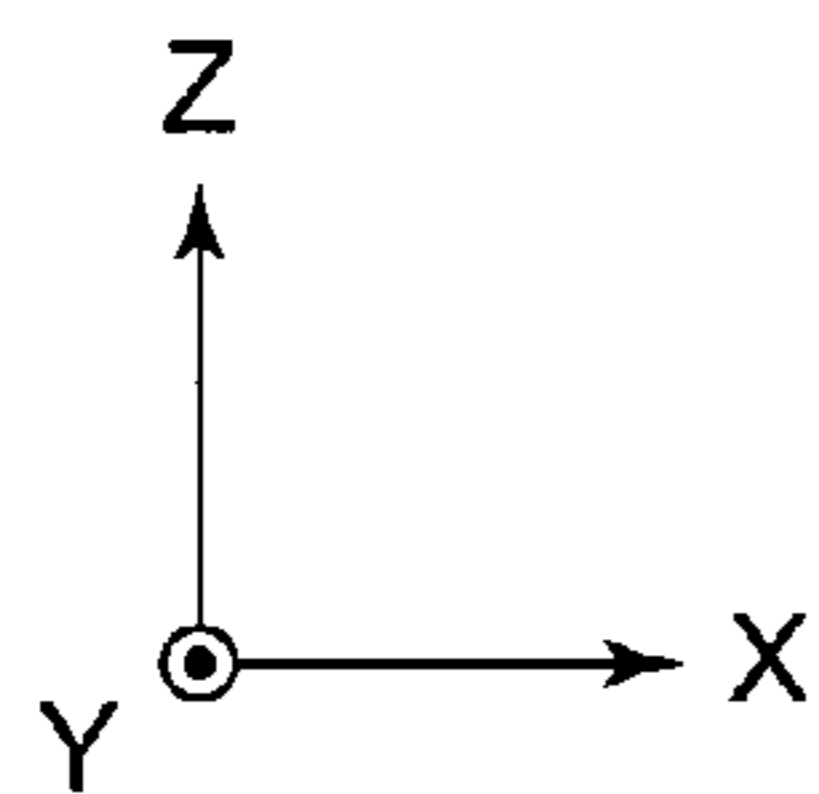
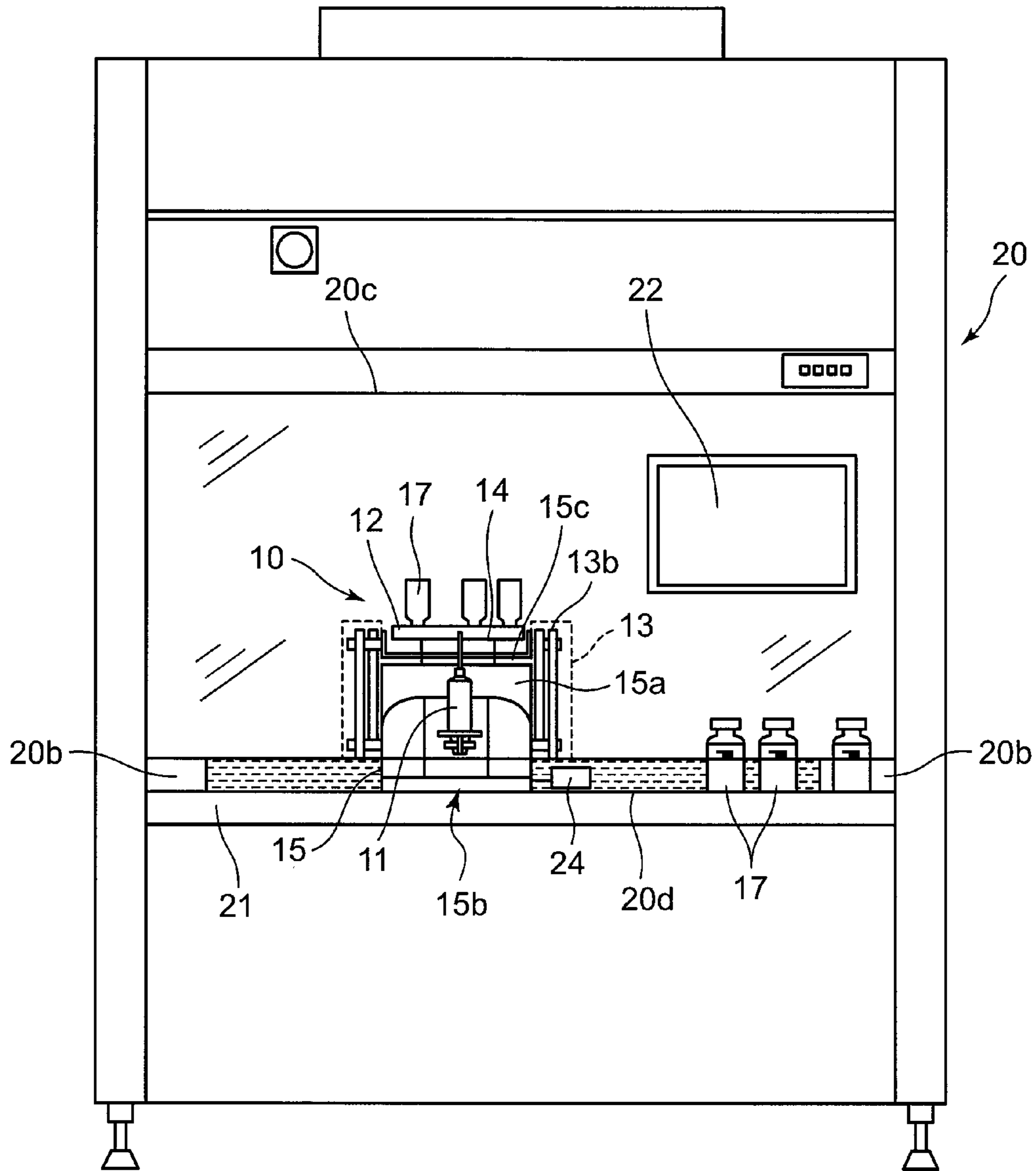


Fig. 10

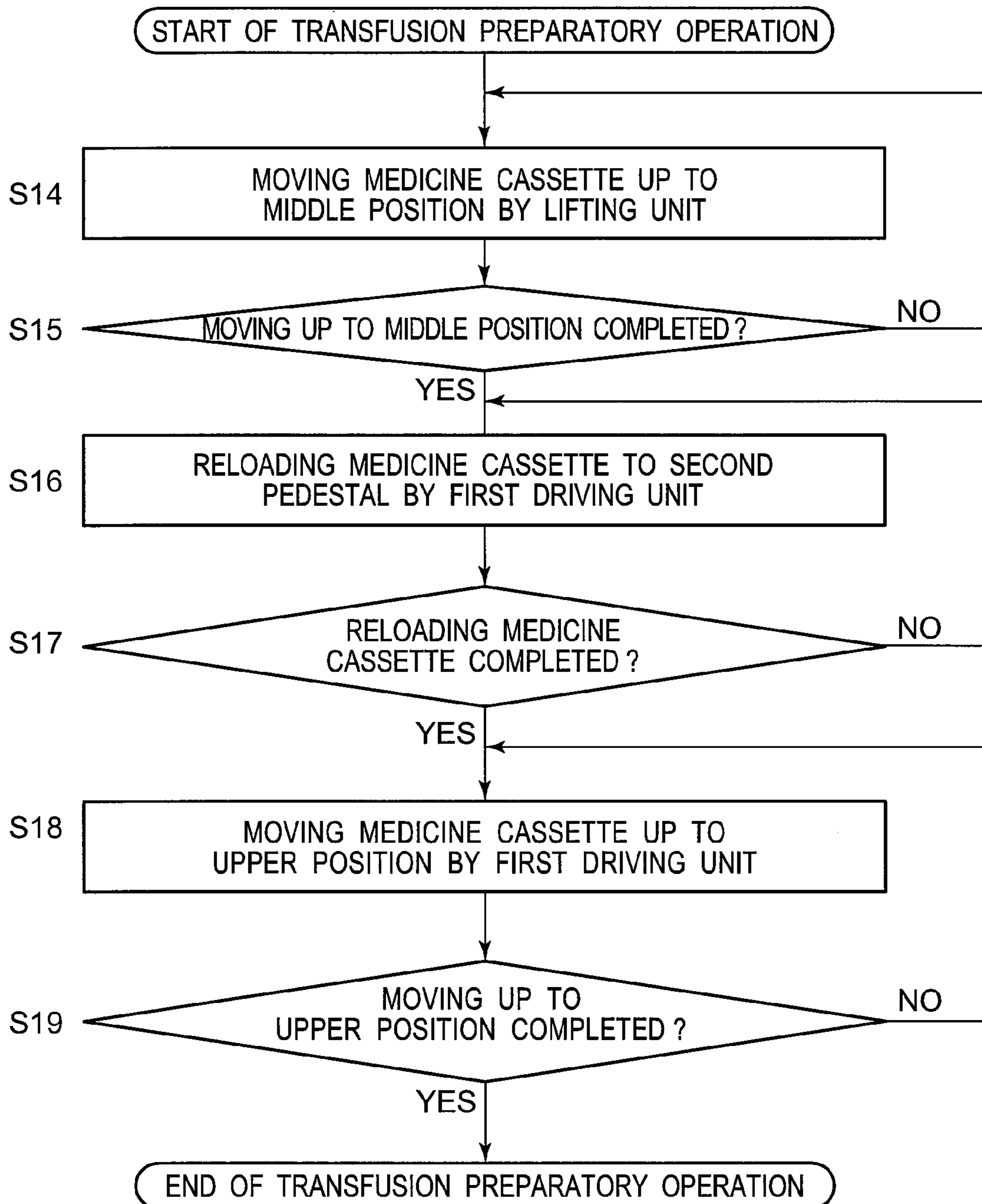


Fig. 11

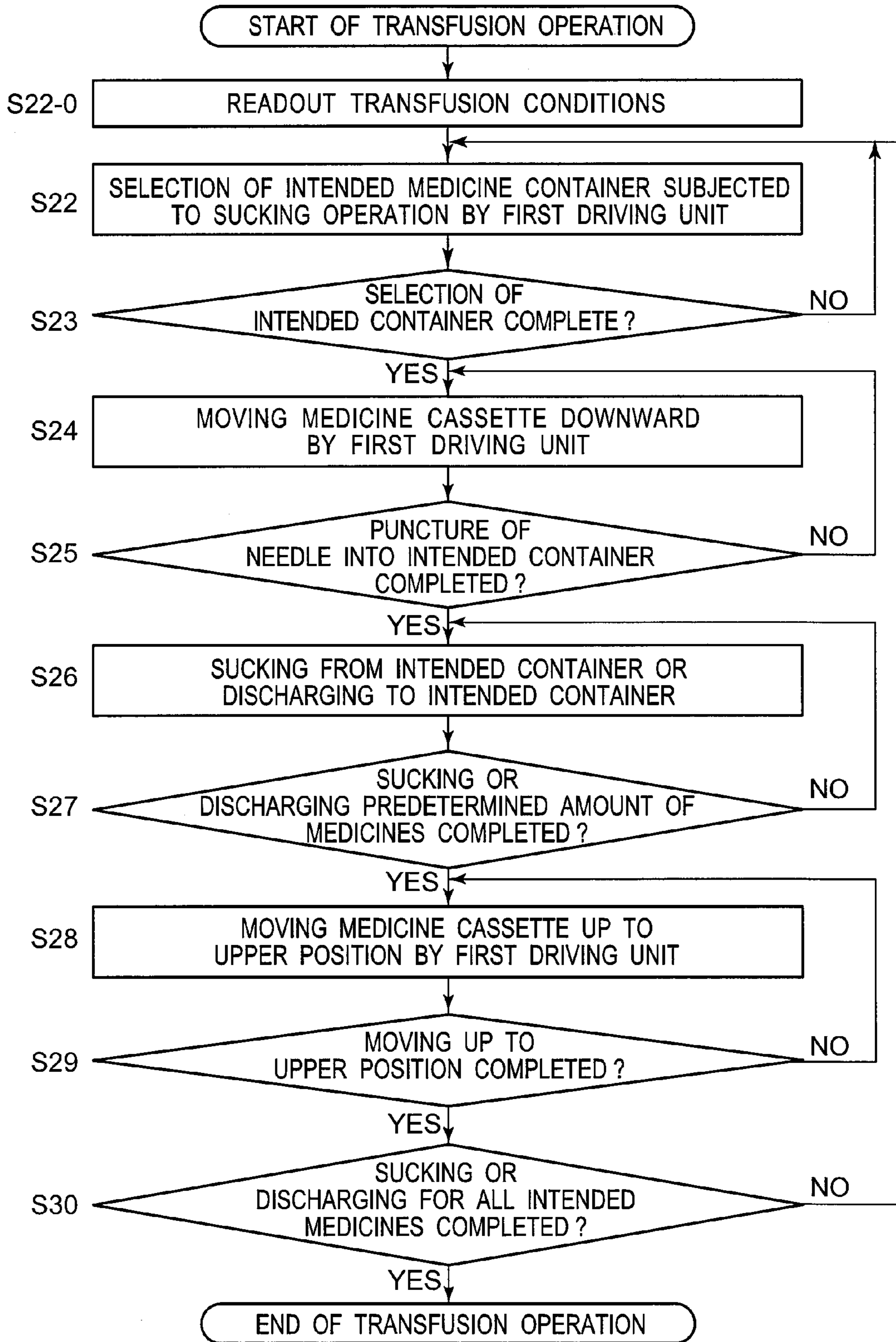
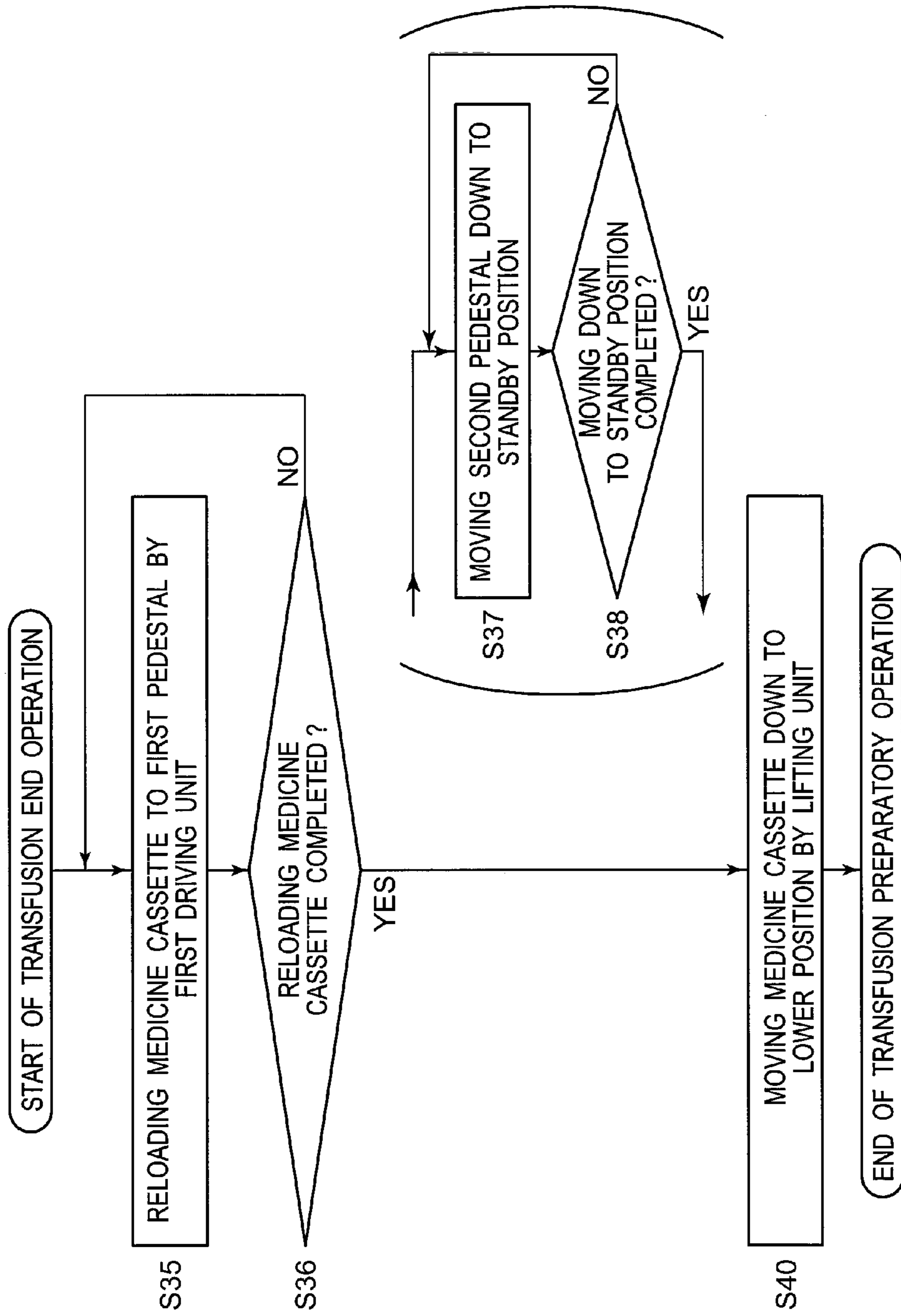


Fig. 12



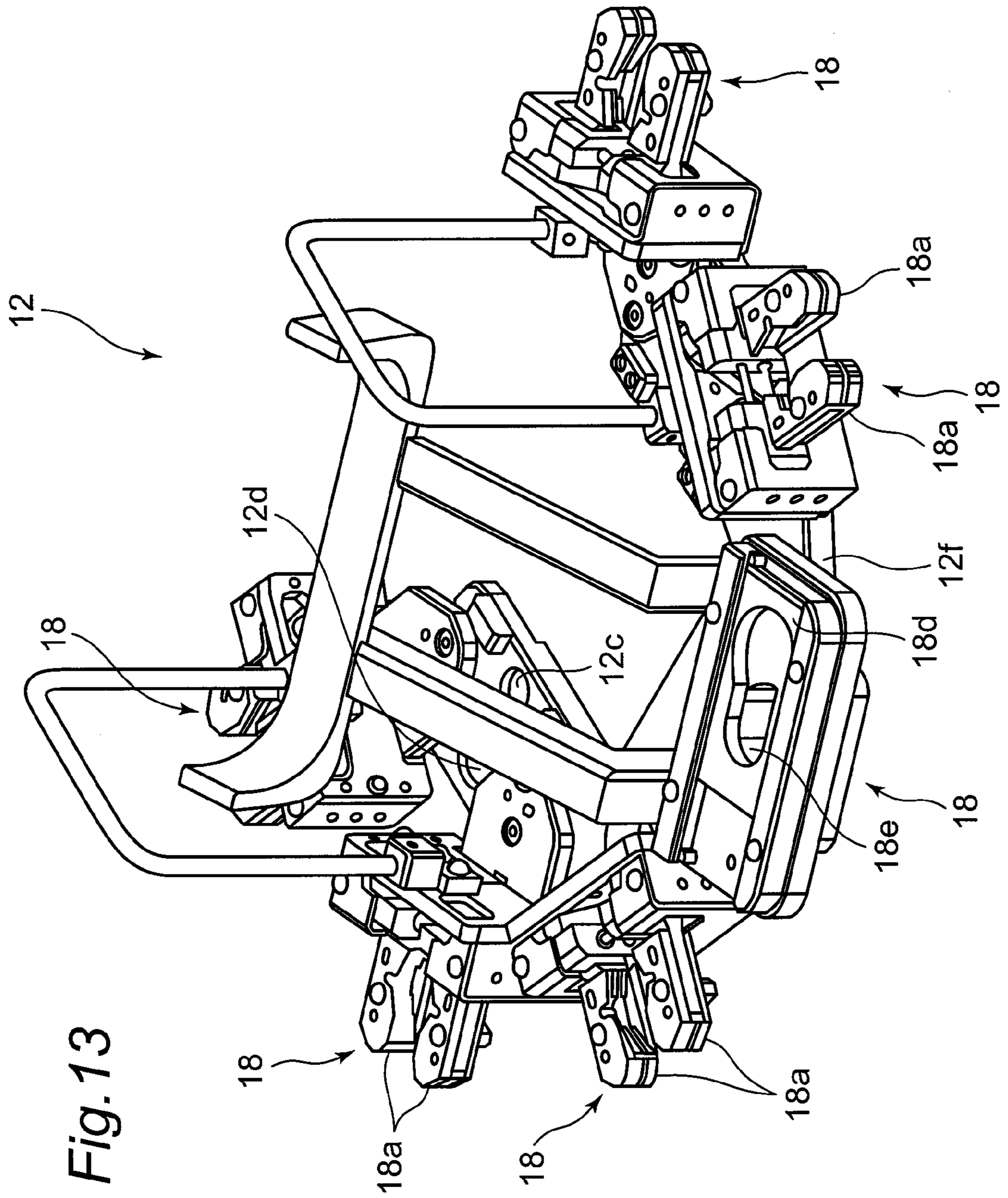
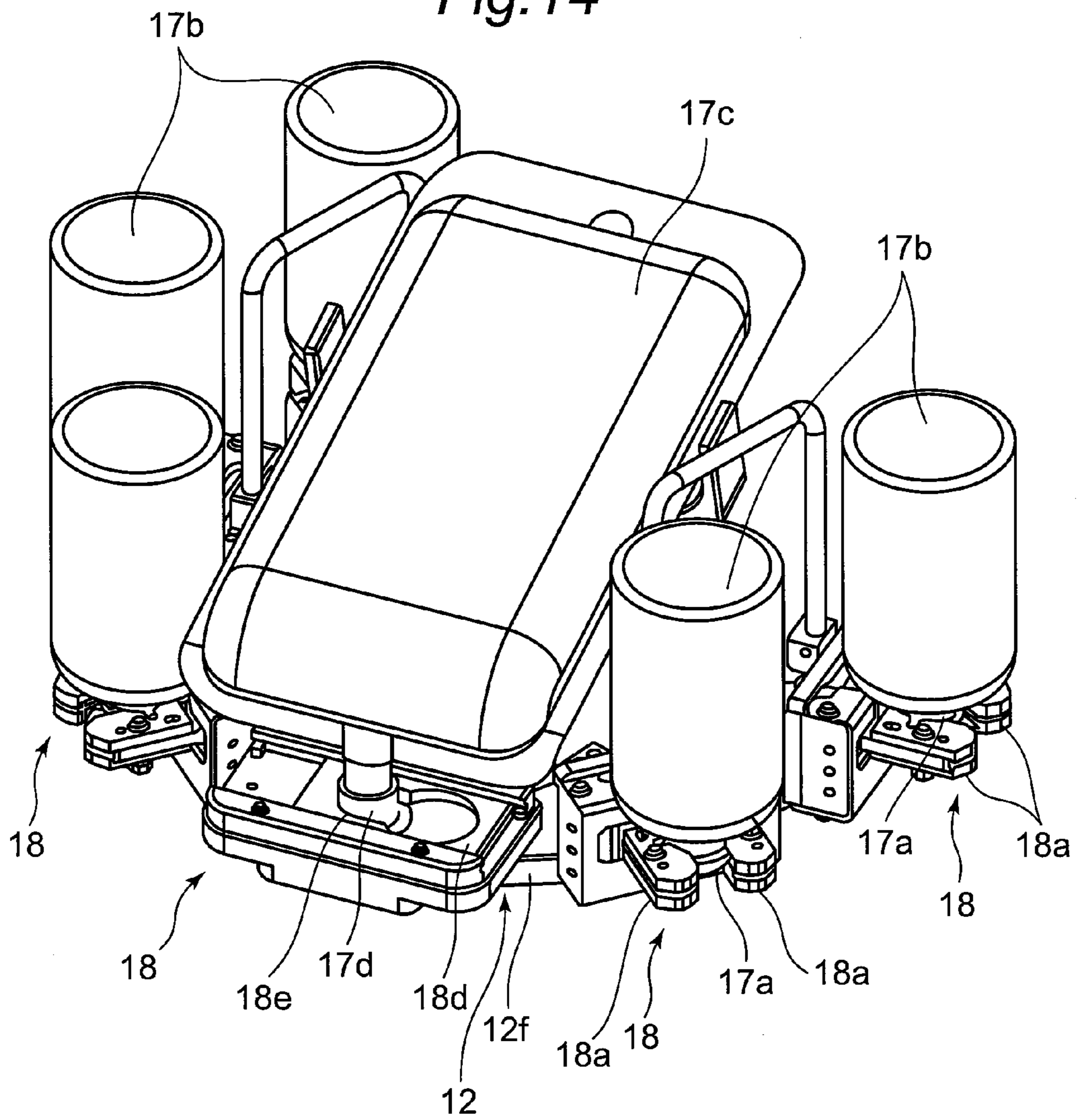
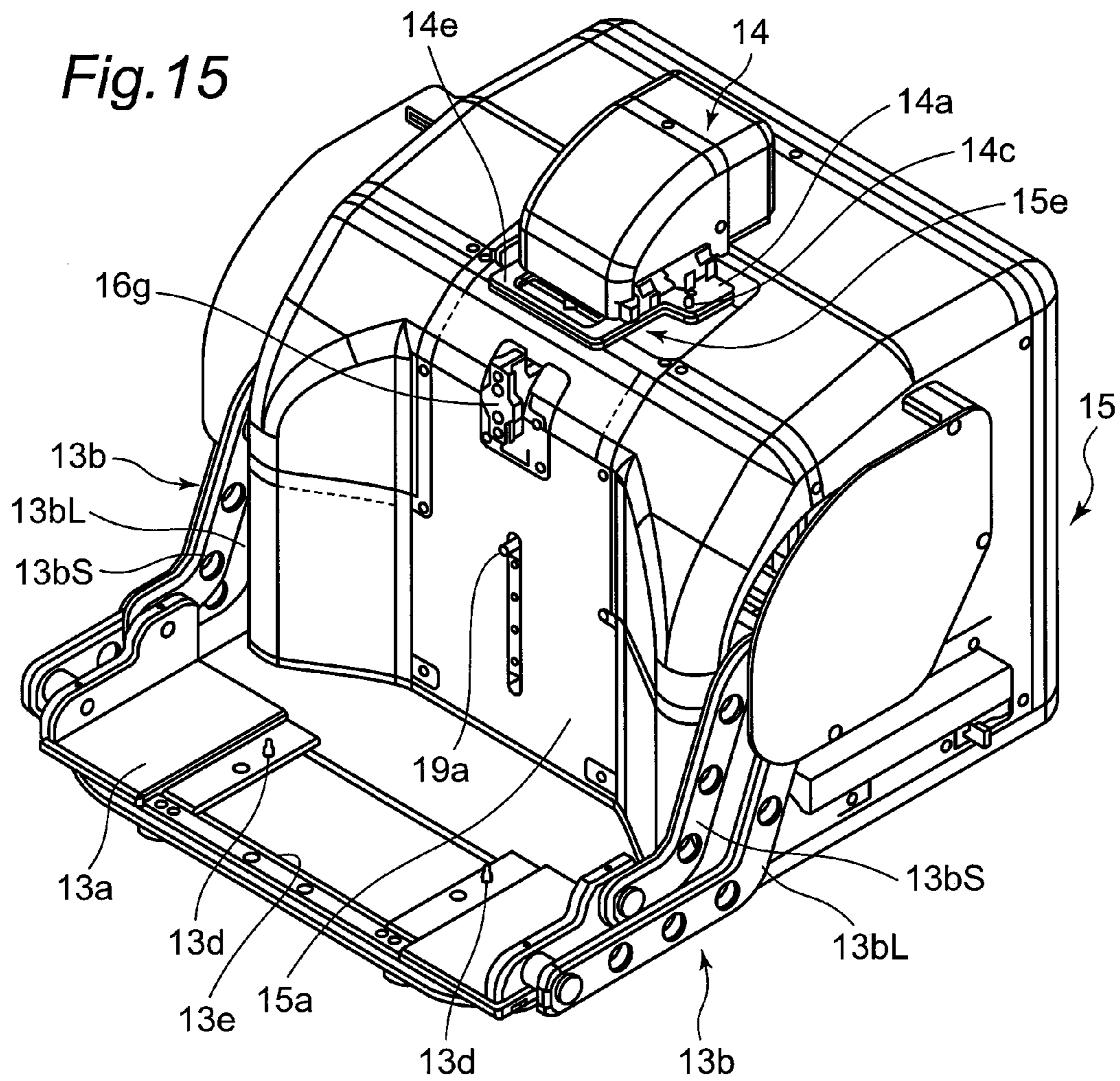
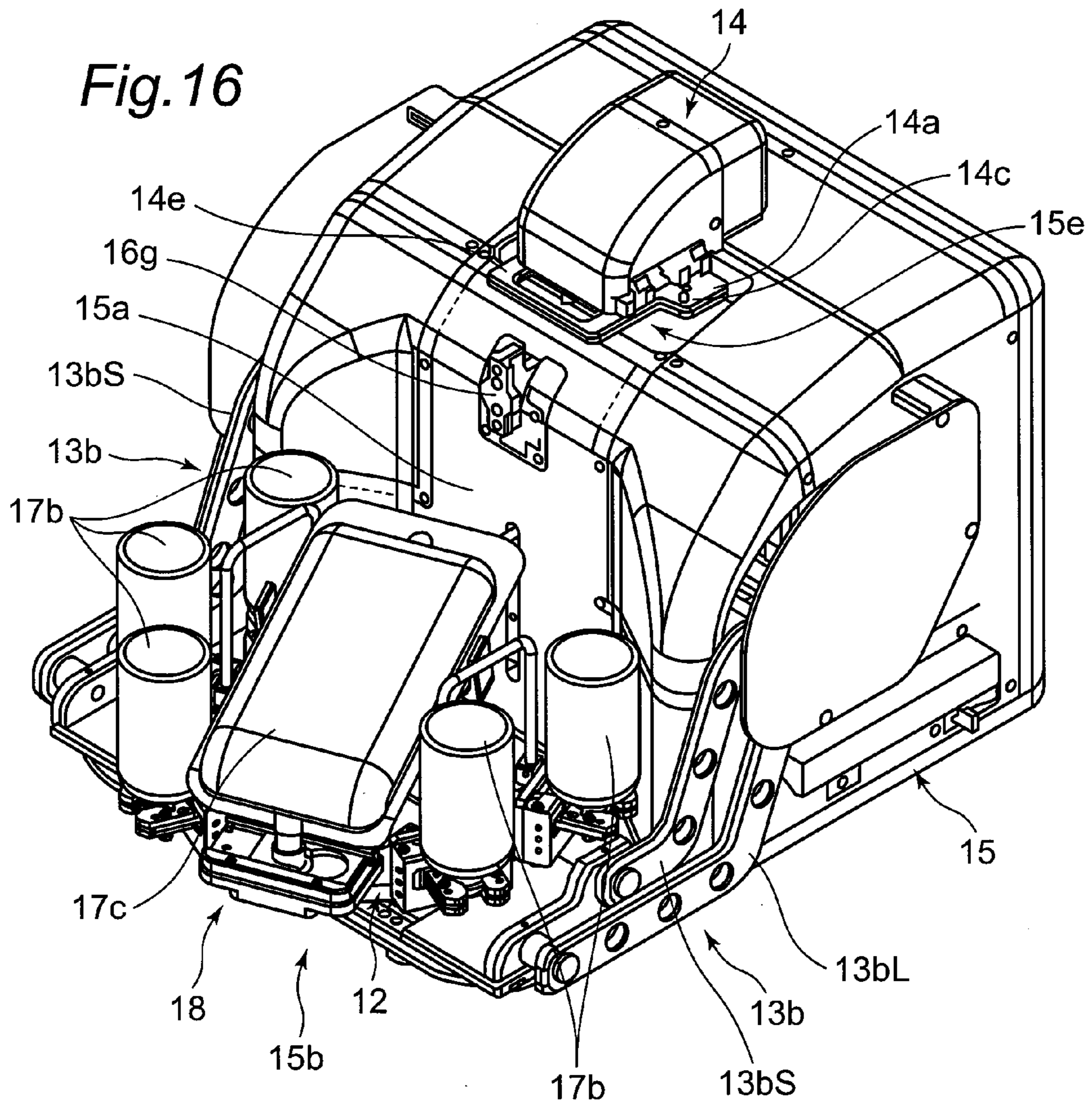


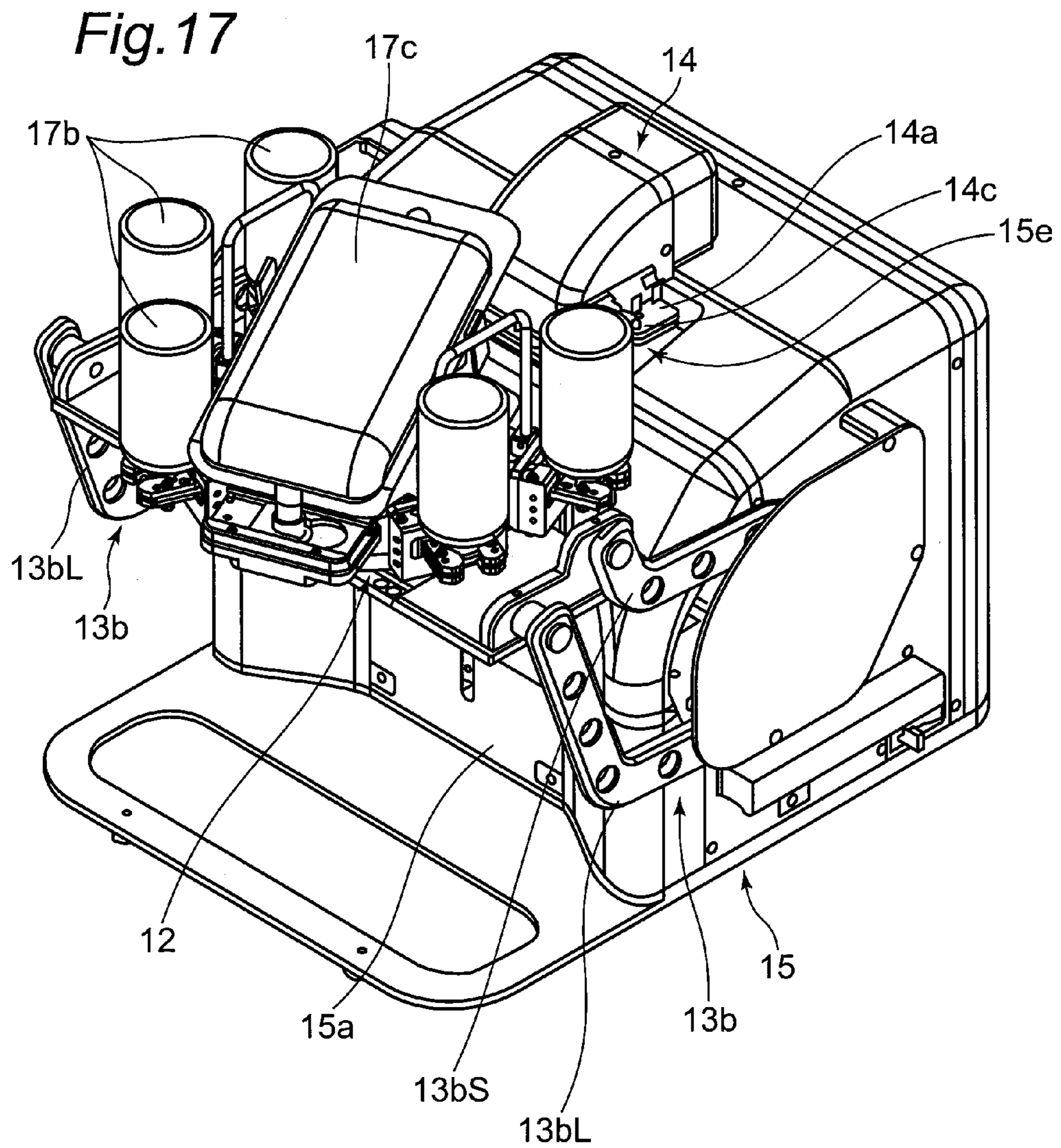
Fig. 13

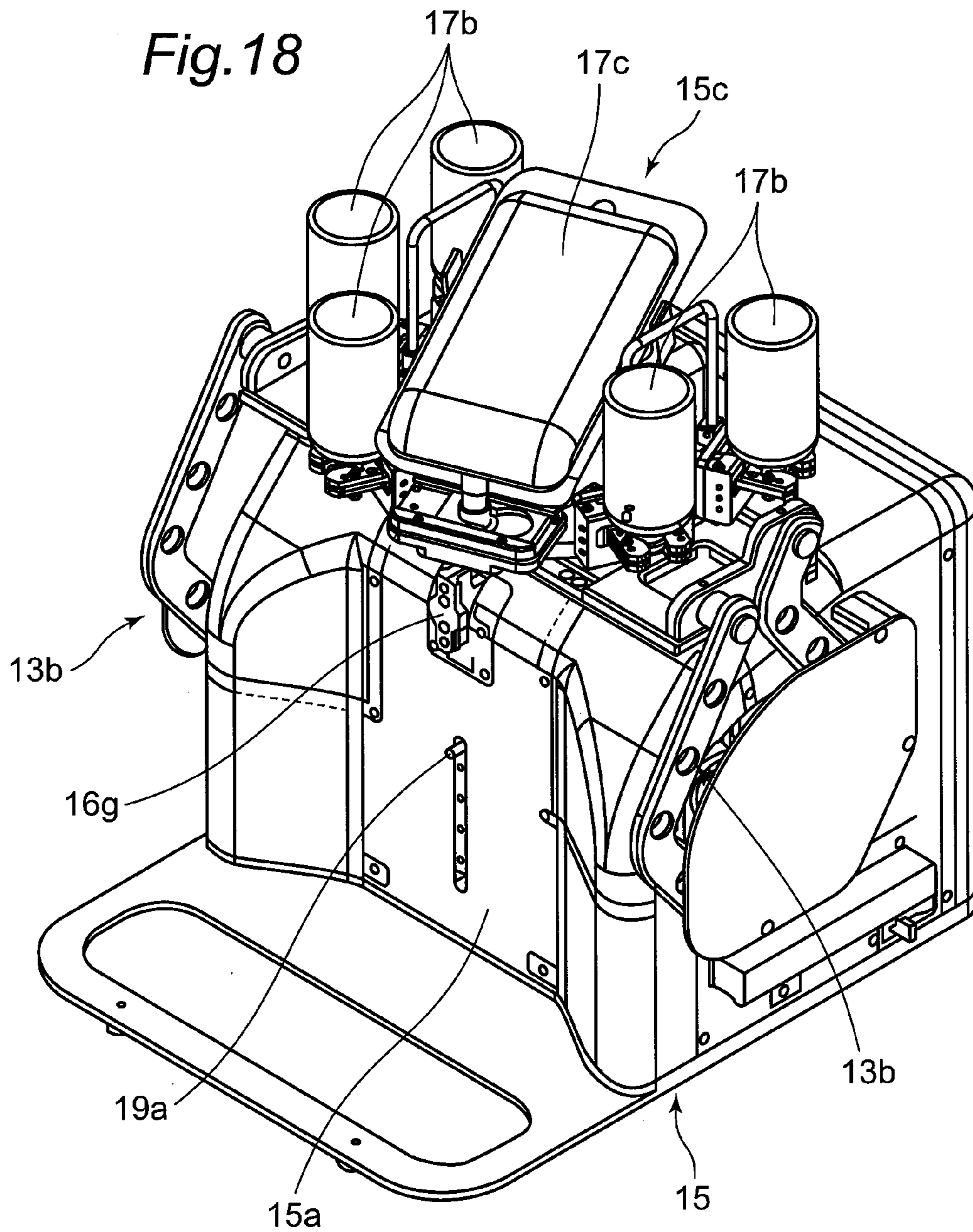
Fig. 14

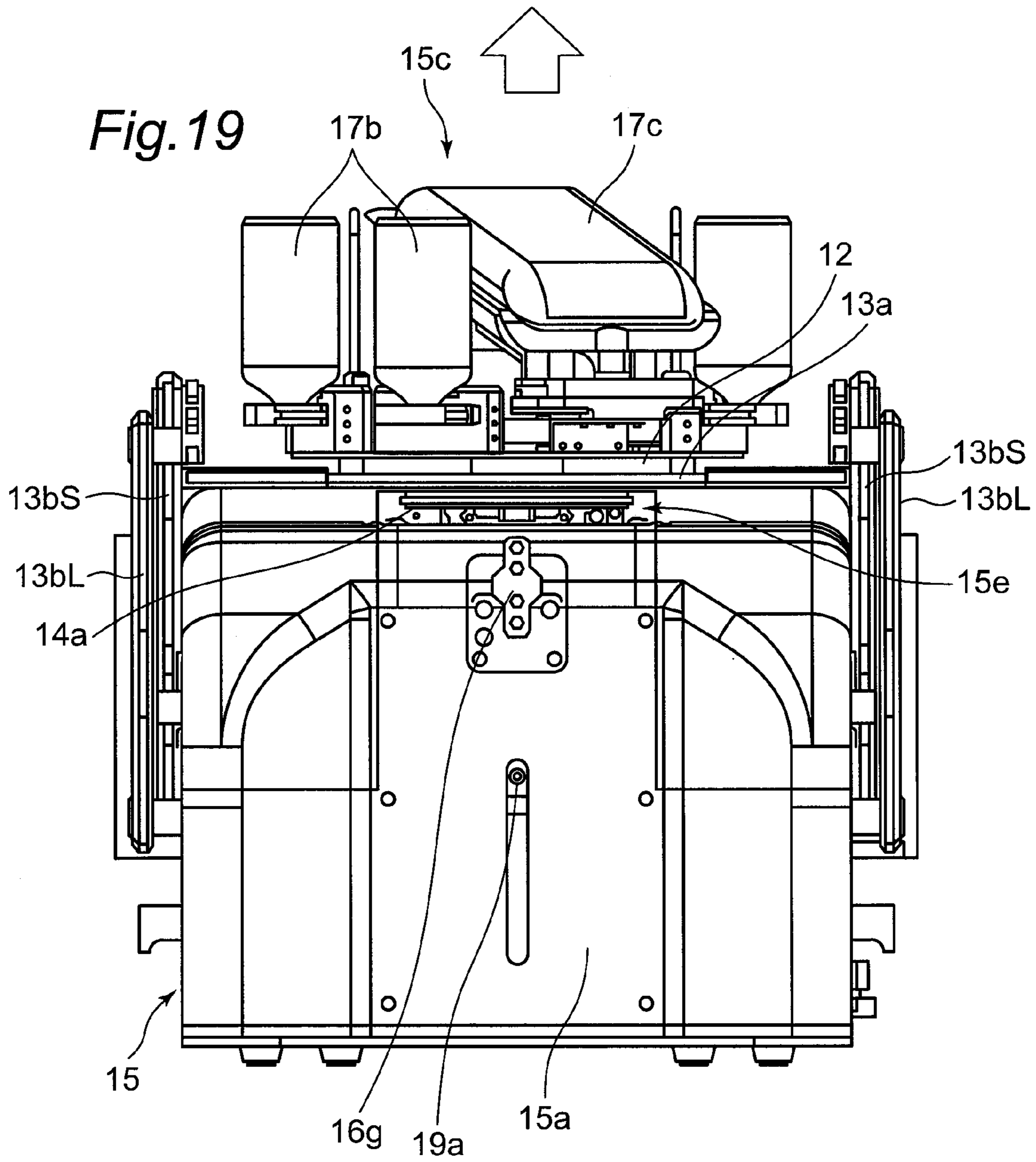


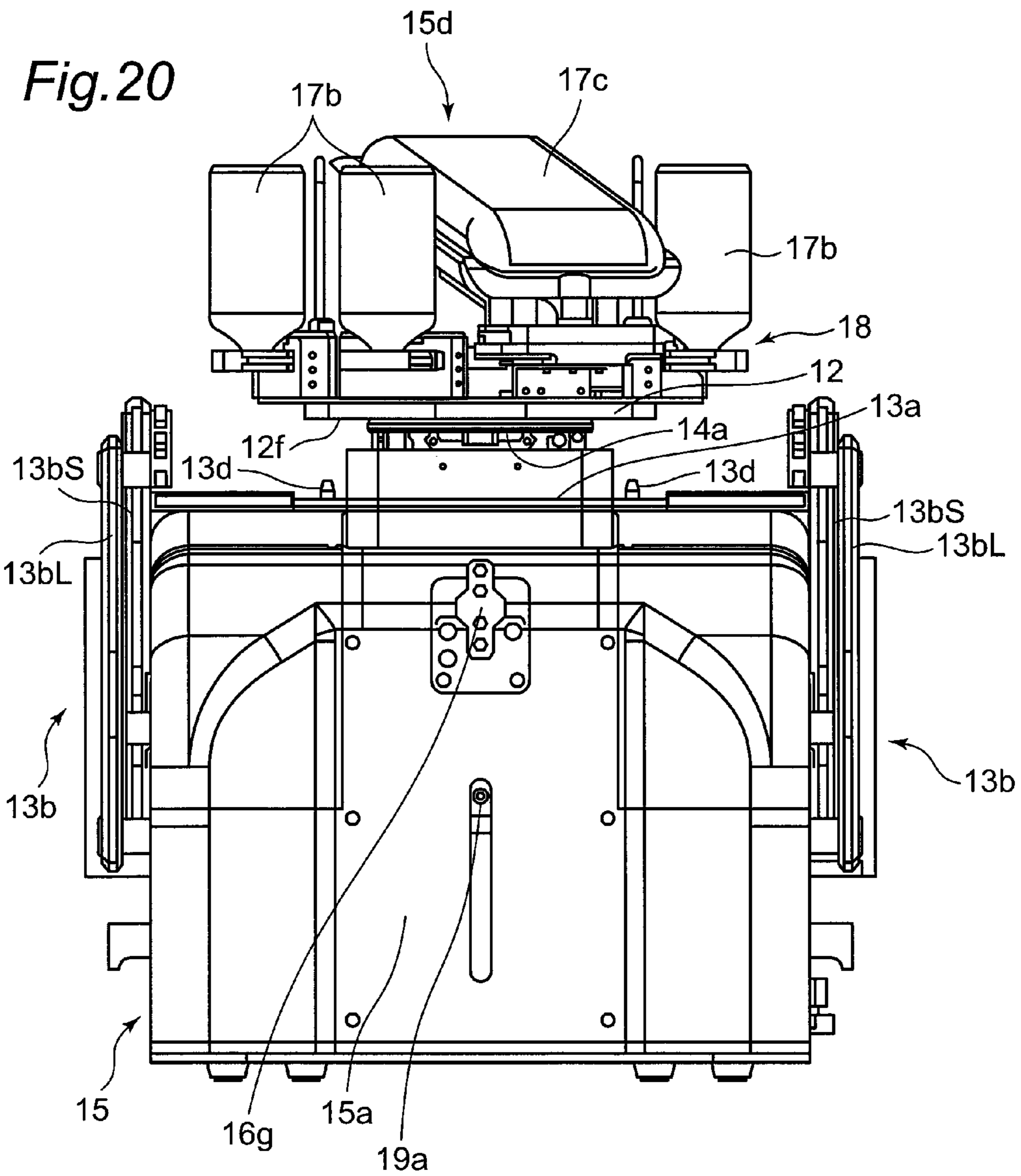


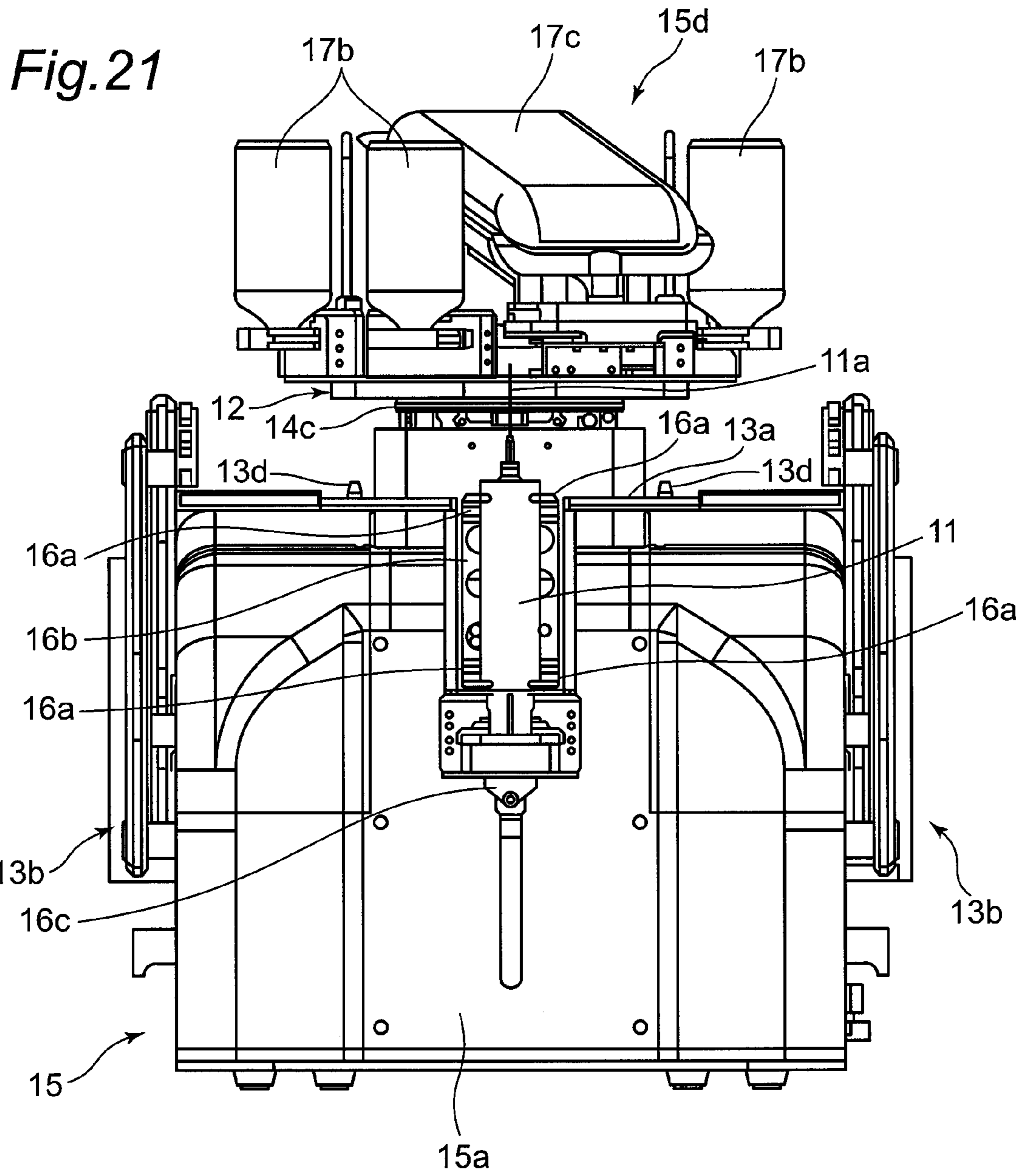


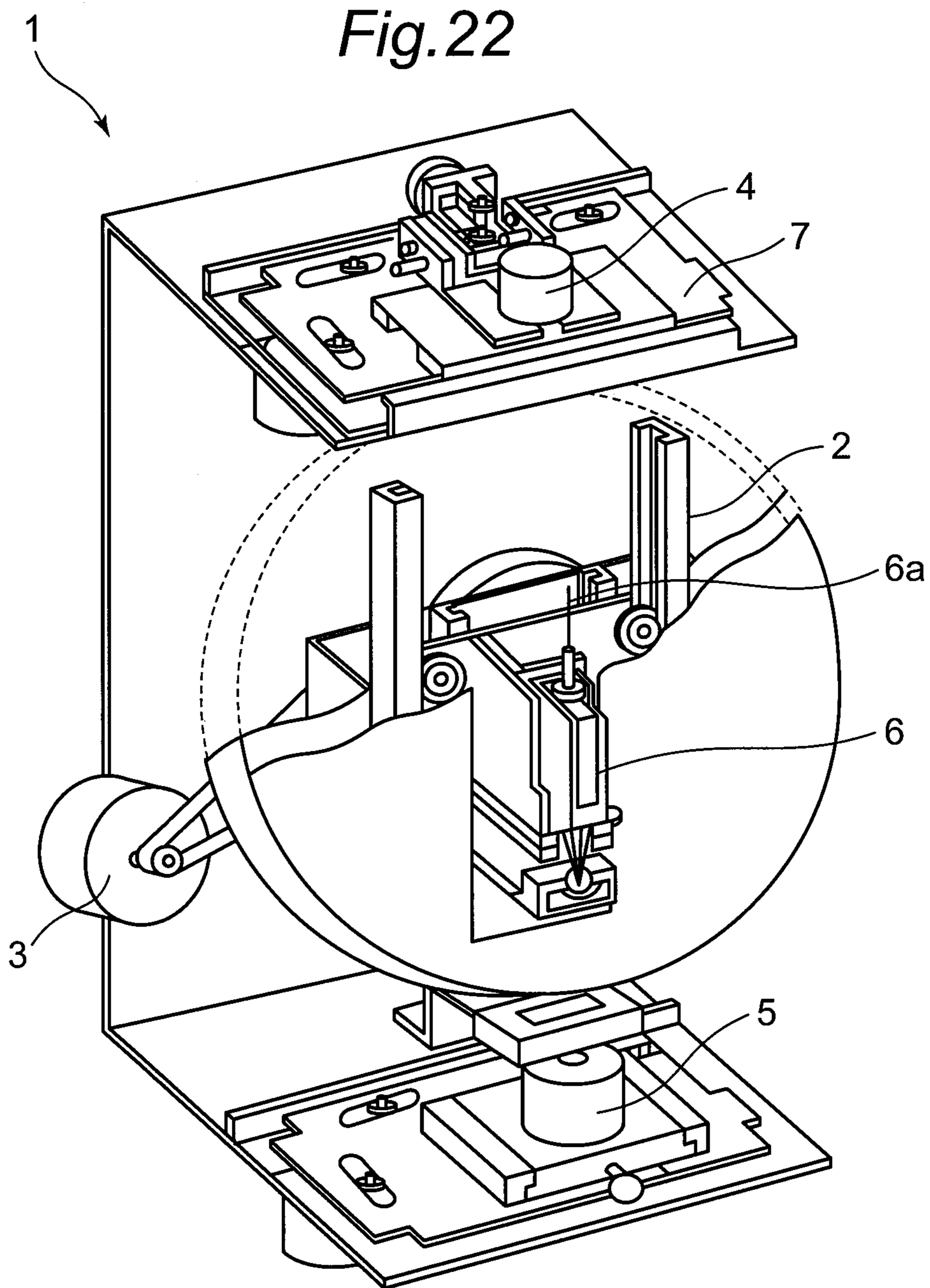












1**MEDICINE TRANSFUSION APPARATUS AND
MEDICINE TRANSFUSION METHOD**

TECHNICAL FIELD

The present invention relates to a medicine transfusion apparatus and a medicine transfusion method transfusing a medicine using a syringe.

BACKGROUND ART

In hospitals, medicines of several kinds taken out from different types of medicine containers may be mixed to prepare a mixture medicine, and the mixture medicine may be administered to inpatients, or the like. Such an operation of mixing medicines is usually performed manually by nurses or pharmacists (hereinafter referred to as an operator), for whom it is a heavy burden. In addition, the medicine containers that contain medicines have variety in type and shape. Also, in a case where an anticancer agent is dissolved by mixing with a liquid medicine, the mixture solution is harmful to humans and can be dangerous if the mixture solution leaks out from the medicine container to external air. Therefore, the mixing of medicines such as an anticancer agent needs to be operated in a work space of the hospital which is designed in consideration of safety (e.g. in a safety cabinet). In other words, operators are required to efficiently perform the mixing operation in the work space designed in consideration of safety. In order to ease such an operation, there has been suggested a device for safely and automatically sucking medicines from medicine containers (see, for example, Patent Literature 1).

FIG. 22 illustrates a structural view of a dispensing device of Patent Literature 1 as an example of a conventional medicine mixing device.

The dispensing device 1 illustrated in FIG. 22 is a device for dispensing radioisotope, i.e., a radioactive medicine that is hard to be handled. The dispensing device 1 dispenses a radioactive medicine from a storage container 4 located at the top of the device into a mixing container 5 located at the bottom of the device by moving an injection syringe 6 by means of a lifting mechanism 2 and a rotating mechanism 3. Radioactive medicines require to be handled with great care. Therefore, the storage container 4 is fixed to the device by a container holding portion 7 provided at the top of the device. The radioactive medicine is sucked into the injection syringe 6 by sticking a needle 6a of the injection syringe 6 into the storage container 4. Subsequently, the injection syringe 6 is moved to a position near the mixing container 5 by means of the lifting mechanism 2 and the rotating mechanism 3, and then the radioactive medicine is dispensed by discharging the radioactive medicine from the injection syringe 6 into the mixing container 5.

CITATION LIST

Patent Literature

Patent Literature 1: Unexamined Japanese Patent Publication No. H01-244759

SUMMARY OF INVENTION

Technical Problem

However, in the above described dispensing device 1, in order to dispense medicines, the injection syringe 6 needs to

2

be moved or rotated in the vertical direction, and thus, there is a problem that the device is increased in size. When the device is increased in size, operators may not be able to perform medicine handling operation near a position on the operator's side.

In order to solve the above described problem, an object of the present invention is to provide a medicine transfusion apparatus and a medicine transfusion method, each of which is capable of being set in a limited space and capable of efficiently transfusing a medicine.

Solution to Problem

In order to achieve the above-described object, the present invention has the following construction.

In order to solve the above problem, a medicine transfusion apparatus according to an aspect of the present invention, is a medicine transfusion apparatus transfusing a medicine between a medicine container and a syringe by the syringe, the medicine transfusion apparatus comprising:

a medicine cassette that holds the medicine container;
a lifting unit that moves the medicine cassette upward and downward between a middle position on an upper portion and a lower position of a main body along an arcuate path while maintaining a horizontal attitude of the medicine cassette using a pair of parallel link mechanisms;

a first holding portion that is capable of holding the syringe and is detachably mounted to the main body;

a first driving unit that relatively moves the medicine cassette and the first holding portion so that a needle of the syringe held by the first holding portion is inserted into the medicine container; and

a second driving unit that drives a plunger of the syringe to transfuse the medicine between the syringe and the medicine container.

In order to solve the above problem, a medicine transfusion method according to the present invention is a medicine transfusion method comprising:

a first step of moving a medicine cassette holding a medicine container upward from a lower position of a main body to a middle position on an upper portion of the main body along an arcuate path while maintaining a horizontal attitude of the medicine cassette by a lifting unit utilizing a pair of parallel link mechanisms;

a second step of reloading the medicine cassette from a first pedestal of the lifting unit to a second pedestal of a first driving unit in the middle position after the first step;

a third step of inserting a needle of a syringe held by a first holding portion into the medicine container held by the medicine cassette after the second step; and

a fourth step of driving a plunger of the syringe to transfuse a medicine between the syringe and the medicine container after the third step.

Effects of Invention

According to each aspect of the present invention, a medicine transfusion apparatus and a medicine transfusion method, each of which is capable of being set in a limited space and capable of efficiently transfusing the medicine and a medicine transfusion method can be achieved.

BRIEF DESCRIPTION OF DRAWINGS

These and other objects and features of the present invention will become clear from the following description

taken in conjunction with the preferable embodiments thereof with reference to the accompanying drawings, in which:

FIG. 1 is a perspective view showing a schematic construction of a medicine mixing device according to a first embodiment of the present invention;

FIG. 2A is a plan view of the medicine mixing device according to the first embodiment of the present invention;

FIG. 2B is a plan view of the medicine mixing device according to the first embodiment of the present invention, in which a state where a medicine cassette is positioned in a middle position in FIG. 2A is illustrated by dotted lines (illustration of a pedestal is omitted);

FIG. 3 is a bottom view showing a schematic construction of a second holding portion in the medicine cassette of the medicine mixing device according to the first embodiment of the present invention;

FIG. 4 is a side view including a partial cross section schematically illustrating a state where a medicine container is fixed to the medicine cassette;

FIG. 5A is a side view outlining an operation in a lifting unit of the medicine mixing device according to the first embodiment of the present invention with a first holding portion being virtually illustrated;

FIG. 5B is a side view outlining an operation in the lifting unit of the medicine mixing device according to the first embodiment of the present invention with the first holding portion being removed;

FIG. 6 is a perspective view of the medicine mixing device according to the first embodiment of the present invention illustrating a state just before the first holding portion is mounted on a main body;

FIG. 7 is a block diagram illustrating the relationship between a controlling section and each driving unit etc. of the medicine mixing device according to the first embodiment of the present invention;

FIG. 8 is a schematic illustrative view for illustrating a driving mechanism of a syringe of the medicine mixing device according to the first embodiment of the present invention;

FIG. 9 is a front view illustrating an example, in which the medicine mixing device according to the first embodiment of the present invention is placed in a small space;

FIG. 10 is a specific flow chart illustrating a medicine mixing method according to the first embodiment of the present invention;

FIG. 11 is a specific flow chart illustrating the medicine mixing method according to the first embodiment of the present invention;

FIG. 12 is a specific flow chart illustrating the medicine mixing method according to the first embodiment of the present invention;

FIG. 13 is a perspective view illustrating the medicine cassette of the medicine mixing device according to the first embodiment of the present invention in a state where the medicine container is not held;

FIG. 14 is a perspective view illustrating the medicine cassette of the medicine mixing device according to the first embodiment of the present invention in a state where the medicine container is held;

FIG. 15 is a perspective view of the medicine mixing device according to the first embodiment of the present invention in a state before the medicine cassette is set on the main body;

FIG. 16 is a perspective view of the medicine mixing device according to the first embodiment of the present invention in a state where the medicine cassette is set on the main body;

FIG. 17 is a perspective view of the medicine mixing device according to the first embodiment of the present invention in a state where the medicine cassette is moved upward from a lower position up to a middle position;

FIG. 18 is a perspective view of the medicine mixing device according to the first embodiment of the present invention in a state where the medicine cassette is positioned in the middle position;

FIG. 19 is a perspective view of the medicine mixing device according to the first embodiment of the present invention in a state before the medicine cassette positioned in the middle position is reloaded from a first pedestal onto a second pedestal;

FIG. 20 is a perspective view of the medicine mixing device according to the first embodiment of the present invention in a state where the medicine cassette positioned in the middle position is reloaded from the first pedestal onto the second pedestal;

FIG. 21 is a perspective view of the medicine mixing device according to the first embodiment of the present invention in a state where the medicine cassette is moved up to an upper position, and in a state where the first holding portion is attached to the main body; and

FIG. 22 is a structural view of a conventional medicine mixing device.

DESCRIPTION OF EMBODIMENTS

An embodiment of the present invention will be described with reference to the drawings. It should be noted that the same constituent elements will be given the same reference numerals, and description thereof will sometimes be omitted. For easy understanding, the drawings are schematic focusing on the constituent elements. Also, axes X, Y, and Z are given in each drawing to facilitate understanding of the relationship of each drawing.

First Embodiment

FIG. 1 is a perspective view showing a schematic construction of a medicine mixing device 10 according to a first embodiment of the present invention. FIG. 2A is a plan view of the medicine mixing device 10 according to the first embodiment. FIG. 2B is a plan view of the medicine mixing device 10, in which a state where a medicine cassette is positioned in a middle position in FIG. 2A is illustrated by dotted lines (illustration of a pedestal is omitted). FIG. 3 is a bottom view showing a schematic construction of a second holding portion 18 in a medicine cassette 12 of the medicine mixing device 10 according to the first embodiment. In should be noted that in FIGS. 2A and 2B, illustration of a syringe 11 and a first holding portion 16 is omitted. FIG. 4 is a side view including a partial cross section schematically illustrating a state where medicine containers 17 are fixed to the medicine cassette 12. FIG. 5A is a side view for outlining operation in a lifting unit 13 of the medicine mixing device 10 according to the first embodiment with the first holding portion 16 being virtually illustrated. FIG. 5B is a side view for outlining operation in the lifting unit 13 of the medicine mixing device 10 according to the first embodiment with the first holding portion 16 being removed. The medicine mixing device 10 according to the first embodiment is a medi-

cine mixing device mixing a medicine such as injection the medicine in the medicine container 17 using the syringe 11.

Here, the first holding portion 16 is one example of a syringe holder that holds the syringe 11, and the second holding portion 18 is one example of a port holder that holds a port portion 17a of the medicine container 17. The lifting unit 13 is one example of a cassette lifting unit that moves the medicine cassette 12 upward and downward between a lower position 15b and a middle position 15c. Herein, the lower position 15b is one example of a lower position where the medicine cassette 12 is to be set, and the middle position 15c is one example of a middle position where the medicine cassette 12 is to be delivered from a first pedestal 13a to a second pedestal 14a. Also, an upper position 15d described below is one example of a medicine transfusing position, which is a home position where the transfusion of the medicine is performed in the first embodiment. Further, the medicine mixing device 10 is one example of a medicine transfusion apparatus transfusing the medicine, according to the first embodiment of the present invention, and a medicine transfusion method in the description below is one example of a medicine transfusion method transfusing the medicine, according to the first embodiment of the present invention. Further, a person, e.g. a nurse or a pharmacist, who performs the operation, is referred to as an operator.

As illustrated in FIG. 1, the medicine mixing device 10 of the first embodiment includes the medicine cassette 12, the lifting unit 13, a first driving unit 14, a main body 15, the first holding portion 16, and a second driving unit 19 (see FIG. 6). The first driving unit functions as one example of a vertical driving mechanism, and is one example of a cassette driving unit driving the medicine cassette 12. The second driving unit 19 is one example of a plunger driving unit driving a plunger 11b of the syringe 11.

As illustrated in FIGS. 2A, 2B, and 13, the medicine cassette 12 is constructed by an arc-shaped fixing unit 12f. FIG. 13 is a perspective view of the medicine cassette 12. The fixing unit 12f has a pair of position regulating holes 12c disposed at the inner-side portion on both ends of an arc-shaped member, and a pair of position regulating holes 12d, each disposed at the outer-side portion of the pair of position regulating holes 12c. Further, the fixing unit 12f includes a plurality of the second holding portions 18 provided along the circumferential direction. Each one of the plurality of the second holding portion 18 is capable of holding one of a plurality of the medicine containers 17. The medicine cassette 12 is positioned with respect to the first pedestal 13a and detachably placed on the first pedestal 13a in such a manner that a pair of positioning pins 13d of the first pedestal 13a in the lifting unit 13 is fitted with respect to the pair of the position regulating holes 12d of the fixing unit 12f.

The first driving unit 14 moves upward the medicine cassette 12 held in the middle position 15c on an upper portion of the main body 15 up to the upper position 15d, and moves the medicine cassette 12 in a vertical direction 31a and in a rotating direction 31b. Further, the first driving unit 14 includes a first driving unit 14U (see FIG. 7) including a motor 14Um and an encoder 14Ue, a second driving unit 14R including a motor 14Rm and an encoder 14Re, and the second pedestal 14a having a T-plate shape.

The first driving unit 14U allows the T-plate shaped second pedestal 14a to vertically move upward and downward and to bring into contact with the fixing unit 12f of the medicine cassette 12. A projection 14e formed at the front side of the T-plate shaped second pedestal 14a is configured to vertically pass through a notch 13e of the first pedestal

13a in the lifting unit 13 (see FIG. 2A). By passing through the notch 13e, the second pedestal 14a is capable of lifting the fixing unit 12f of the medicine cassette 12 that is detachably placed on the first pedestal 13a upward from the first pedestal 13a. When the medicine cassette 12 is reloaded from the first pedestal 13a onto the second pedestal 14a, in the first embodiment, the pair of positioning pins 13d of the first pedestal 13a is disengaged from the pair of position regulating holes 12d of the medicine cassette 12, and a pair of positioning pins 14c of the second pedestal 14a is fitted into the pair of position regulating holes 12c of the medicine cassette 12. The medicine cassette 12 positioned in the middle position 15c can be reloaded from the first pedestal 13a onto the second pedestal 14a by utilizing the notch 13e. The pair of positioning pins 14c is stood upward at both ends of a base part side of the second pedestal 14a. The pair of positioning pins 14c is configured to be engageable to or disengageable from the pair of position regulating holes 12c of the medicine cassette 12 in the middle position 15c. The second driving unit 14R and the first driving unit 14U are provided with detectors (see FIG. 7) including the encoders 14Ue and 14Re that detect signals (e.g. rotational angle signals of motor shafts) outputted from the respective motors 14Rm and 14Um. On the basis of the signals detected by the encoders 14Ue and 14Re, the second driving unit 14R and the first driving unit 14U respectively control the rotation driving of the motors 14Rm and 14Um in forward and reverse directions in a controlling section 100, thereby performing predetermined moving up-down operation and rotating operation.

In the first driving unit 14U, the fixing unit 12f of the medicine cassette 12 is reloaded from the first pedestal 13a onto the second pedestal 14a to move the medicine cassette 12 from the middle position 15c to the upper position 15d. After that, the medicine cassette 12 is moved upward integrally with the second pedestal 14a in the vertical direction 31a, and then, the medicine cassette 12 is moved to the upper position 15d. In the upper position 15d, the medicine cassette 12 is driven up and down by the first driving unit 14 in the vertical direction 31a parallel to an arrow 35, and is driven to rotate in the rotating direction 31b. The medicine cassette 12 inserts and ejects a needle 11a of the syringe 11 with respect to the medicine container 17 by being driven up and down in the vertical direction 31a. Further, the medicine cassette 12 changes the position of each of the plurality of the medicine containers 17 with respect to the needle 11a of the syringe 11 by being driven to rotate in the rotating direction 31b. Here, the upper position 15d, which is the home position, is a position where the entire medicine cassette 12 including the port portion 17a of the medicine container 17 can be rotated in the rotating direction 31b without interfering with the tip of the needle 11a of the syringe 11. On the other hand, after the transfusion of the medicine is completed, the second pedestal 14a and the medicine cassette 12 are integrally moved downward from the upper position 15d to the middle position 15c. Then, the pair of positioning pins 13d of the first pedestal 13a is fitted into the pair of position regulating holes 12d of the medicine cassette 12, and the pair of positioning pins 14c of the second pedestal 14a is passed downward through the pair of position regulating holes 12c of the medicine cassette 12, thereby delivering the medicine cassette 12.

As illustrated in FIG. 4, an example of the medicine container 17 includes a plurality of vial bottles 17b, or an infusion bag 17c. Each medicine container 17 contains a medicine for being mixed or transfused. Each of the port

portions **17a** and a port portion **17d** of the medicine container **17** is fixed to the second holding portion **18**. That is, as illustrated in FIGS. **3** and **4**, the port portion **17a** of the vial bottle **17b** and the port portion **17d** of the infusion bag **17c** are sandwiched from right and left sides by the second holding portions **18** of the medicine cassette **12**, so that the plurality of the medicine containers **17** are held in an inverted position by the medicine cassette **12** with the port portions **17a** and **17b** being oriented downward.

Each of the second holding portions **18** includes, specifically as illustrated in FIGS. **3**, **7**, **13** and **14**, a left and right pair of fixing plates **18a** that is movable in conjunction with each other, and an elastic member **18c**, such as a spring applying a biasing force toward the closing direction of the pair of fixing plates **18a**. The left and right pair of fixing plate **18a** has a recess **18b** on an each opposing surface thereof where the port portions **17a** and **17d** can be held, and is configured to be movable in the direction of an arrow **34**. It should be noted that FIG. **3** is a bottom view as seen from bottom to top of the second holding portion **18**, and the vial bottle **17b** is held in an inverted position by the second holding portion **18**. The left and right pair of fixing plates **18a** of the second holding portion **18** moves in conjunction with each other by a biasing force applied from the elastic member **18c** in the direction of the arrow **34**, by which the port portion **17a** of the medicine container **17** is fixed or unfixes. In schematic illustrative views of FIGS. **2A** and **2B**, the port portions **17a** of three medicine containers **17** (e.g. vial bottles **17b**) are fixed to the respective second holding portions **18**. Further, in FIGS. **13** and **14**, the port portion **17d** of the infusion bag **17c** is engaged and held in such a manner that an engaging plate **18d** is slidably fixed to the port portion **17d** in an engaging hole **18e**, the engaging hole **18e** being another example of the second holding portion **18**. For one example, in FIGS. **13** and **14**, the port portion **17d** of the infusion bag **17c** is held at the center of the fixing unit **12f** of the medicine cassette **12** by the engaging plate **18d** of the second holding portion **18**, and at each side of the engaging plate **18d**, the port portions **17a** of the plurality of vial bottles **17b** are disposed to be held by a pair of the fixing plates **18a** of the second holding portion **18**.

Use of the medicine cassette **12** configured as described above allows the plurality of the medicine container **17** to be efficiently disposed in a small space in the medicine mixing device **10**, and the desired medicine container **17** can be positioned at a medicine extraction position **15g** by arcuately rotating the medicine cassette **12**. As used herein, the medicine extraction position **15g** is a position in the medicine mixing device **10**, the position opposing the tip of the needle **11a** of the syringe **11** held by the first holding portion **16**.

The lifting unit **13** includes, as illustrated in FIGS. **2A**, **2B**, and **15**, the plate like first pedestal **13a** having the notch **13e** at the center thereof, a pair of parallel link mechanisms **13b** each having one end being rotatably coupled to each side wall of the first pedestal **13a**, and a fourth driving unit **13M** (see FIG. **7**). The fourth driving unit **13M** is disposed in the main body **15**, and includes an encoder **13Me** and a motor **13Mm** to which the other end of the pair of parallel link mechanisms **13b** is each coupled so that the pair of parallel link mechanisms **13b** is driven to rotate in forward and reverse directions in synchronism with each other. On the basis signals obtained by detecting the rotation angle of the motor **13Mm** by the encoder **13Me** or the like, the controlling section **100** controls the rotation driving of the motor **13Mm** in forward and reverse directions, so that the pair of parallel link mechanisms **13b** is rotated in clockwise

or counterclockwise direction in synchronism with each other. When the pair of parallel link mechanisms **13b** is rotated in synchronism with each other, it is ensured that the first pedestal **13a** can be rotated and moved upward and downward in an arcuate direction indicated by an arrow **32** along the forward surface of the main body **15** and along the arcuate path between the lower position **15b** and the middle position **15c** on the forward side of the main body **15** (see FIGS. **16** to **18**). At this time, since the pair of positioning pins **13d** of the first pedestal **13a** is fitted into the pair of position regulating holes **12d** of the medicine cassette **12**, the positioning is thereby maintained even though the medicine cassette **12** moves between the lower position **15b** and the middle position **15c**.

Here, as illustrated in FIG. **1**, each of the parallel link mechanisms **13b** of the first embodiment is constructed by a single S-shaped member **13bS** and a single L-shaped member **13bL**, which have shapes designed not to contact and interfere with each other during the rotating operation.

As seen from the drawings including FIG. **5A**, in the lower position **15b**, the parallel link mechanism **13b** of the first embodiment is configured such that the L-shaped link **13bL** is disposed vertically below the S-shaped link **13bS**.

Also, as seen from the drawings including FIG. **5B**, the parallel link mechanism **13b** of the first embodiment has a shape where a line **L1** and a line **L2** are parallel to each other and form two sides of a parallelogram in the lower position **15b**, and where a line **L3** and a line **L4** are parallel to each other and form two sides of a parallelogram in the middle position **15c**. Here, the lines **L1** to **L4** are lines connecting between the centers of rotation of the portions each of which is rotatably coupled with the first pedestal **13a**, the portions corresponding to the members holding the main body **15** and the medicine cassette **12** at the opposed ends of the L-shaped link **13bL** and at the opposed ends of the S-shaped link **13bS**.

In the first embodiment, use of the S-shaped member **13bS** and the L-shaped member **13bL** configured as described above keeps the parallel link mechanism **13b** out of the way of the operation as much as possible when an operator moves the first pedestal **13a** of the lifting unit **13** to the lower position **15b** to laterally remove the medicine cassette **12** from the main body **15**. It should be noted that the lower position **15b** of the main body **15** is, as illustrated in FIG. **9**, positioned in the proximity of a workbench **21** of a safety cabinet **20**, and is a position where the operator installs the medicine cassette **12** to the first pedestal **13a** of the lifting unit **13** in the main body **15** and removes the medicine cassette **12** from the first pedestal **13a**. Meanwhile, as illustrated in FIG. **9**, the middle position **15c** of the main body **15** is a position that is upwardly away from a working surface **21** of the safety cabinet **20**, and is a position where the operation of mixing the medicine can be safely performed in a place away from the operator.

As described above, in the medicine mixing device **10** of the first embodiment, use of the pair of parallel link mechanisms **13b** allows the medicine cassette **12** on the first pedestal **13a** to be moved upward and downward along the arcuate path that extends along the proximity of a forward surface **15a** of the main body **15**, while maintaining the horizontal attitude of the medicine container **17** supported by the medicine cassette **12**. The medicine container **17** supported by the medicine cassette **12** is moved upward and downward while maintaining the horizontal attitude, thereby allowing to prevent the medicine cassette **12** from falling out of the first pedestal **13a** of the lifting unit **13** or preventing vibrations to the medicine in the medicine container **17** on

the medicine cassette **12** and foaming of the medicine associated with the vibrations.

As illustrated in FIGS. **6** and **21**, the first holding portion **16** is detachably held by the forward surface **15a** of the main body **15** by detachably engaging an engaging hook (not illustrated) of the first holding portion **16** to an engaging groove **16g** of the forward surface **15a**. The first holding portion **16** includes: a base **16b** in a plate-like shape; V-groove shaped claws **16a** fixed at upper and lower portions of the base **16b**, for detachably and laterally sandwiching and holding the syringe **11**; and a coupling portion **16c** coupled to a fifth driving unit **19M**. The coupling portion **16c** holds a plunger **11b** of the syringe **11** and then, vertically moves integrally with the plunger **11b** in the vertical direction of an arrow **33**, and is coupled with a plunger driving pin **19a** coupled to the fifth driving unit **19M** in the main body **15**. In order that the first holding portion **16** and the syringe **11** do not contact with the medicine cassette **12**, in the first embodiment, the medicine cassette **12** is placed on the first pedestal **13a**, and is moved from the lower position **15b** up to the middle position **15c**. After that, the first holding portion **16** is mounted on the main body **15**. In other words, when the medicine cassette **12** is placed on the first pedestal **13a** and is moved from the lower position **15b** up to the middle position **15c**, and conversely, is moved downward from the middle position **15c** to the lower position **15b**, the first holding portion **16** and the syringe **11** are removed from the main body **15**. The configuration as described above realizes a reduction of the depth direction size of the entire device.

The second driving unit **19** includes the driving pin **19a** coupling with the coupling portion **16c** of the first holding portion **16**, and the fifth driving unit **19M** that vertically drives the driving pin **19a**. The fifth driving unit **19M** includes, for one example, as illustrated in FIGS. **7** and **8**, a motor **19Mm**, an encoder **19Me** that detects signals (e.g. rotational angle signals of the motor shaft) outputted from the motor **19Mm** so that the motor **19Mm** can be controlled in the controlling section **100**, a ball screw **19x** that rotates in forward and reverse directions by the rotation of the motor **19Mm** in forward and reverse directions, and a nut member **19y** that vertically moves the ball screw **19x** being threadably engaged therewith (see FIG. **7**). In FIGS. **6** and **15**, the driving pin **19a** being coupled to the coupling portion **16c** projects from the forward surface **15a** of the main body **15**, and the driving pin **19a** is removably engaged with the plunger **11b**. In a state where the driving pin **19a** is coupled with the coupling portion **16c**, the driving pin **19a** is vertically driven by the rotation of the motor **19Mm** in forward and reverse directions, thereby vertically driving the plunger **11b**. The fifth driving unit **19M** drives the plunger **11b** via the driving pin **19a**, so that the syringe **11** sucks a predetermined amount of medicine from the medicine container **17**, or discharges the medicine from the syringe **11** to the medicine container **17**.

As illustrated in FIG. **7**, the medicine mixing device **10** further includes the controlling section **100**. The controlling section **100** controls drives of the second driving unit **14R**, the first driving unit **14U**, the fourth driving unit **13M**, and the fifth driving unit **19M** on the basis of instructions inputted from an operation panel **24** to execute respective predetermined operations.

Further, the operation panel **24** (see FIGS. **2A** and **2B**) is disposed in the proximity of the lower position **15b** of the medicine mixing device **10**, the operation panel **24** allowing an operator to perform all the operations in proximity to the lower position **15b**. The operation panel **24** has a delivery

start button **24a**, a setting completion button **24b**, a mounting completion button **24c**, a removal completion button **24d**, a dispensing completion button **24e**, and an operation completion button **24f**.

The outline of the method mixing the medicine by using the medicine mixing device **10** of the first embodiment will now be briefly described.

First, in a state where the first holding portion **16** and the syringe **11** have not been mounted on the main body **15**, an operator (e.g. a nurse or a pharmacist) sets the medicine cassette **12** on the first pedestal **13a** of the lifting unit **13** in the lower position **15b** of the main body **15** (see preparatory operation prior to Step **S14** to be described later).

When the operator starts mixing the medicine by operating the operation panel **24** (see FIGS. **2A** and **2B**), the driving of the fourth driving unit **13M** of the lifting unit **13** is controlled under the control from the controlling section **100**, so that the medicine cassette **12** together with the first pedestal **13a** is moved upward from the lower position **15b** up to the middle position **15c** of the main body **15** via the pair of parallel link mechanisms **13b** (see Steps **S14** and **S15** to be described later).

After that, when the driving of the first driving unit **14U** of the first driving unit **14** is controlled under the control from the controlling section **100**, the medicine cassette **12** is reloaded from the first pedestal **13a** to the second pedestal **14a**, and then the medicine cassette **12** is moved upward from the middle position **15c** up to the upper position **15d** (see Steps **S16** to **S19** to be described later).

Next, the operator mounts the syringe **11** on the main body **15** together with the first holding portion **16**.

After that, when the driving of the second driving unit **14R** is controlled under the control from the controlling section **100**, the medicine cassette **12** is rotated in the rotating direction **31b**, so that the desired medicine container **17** (intended medicine container) is selected and disposed on the medicine extraction position **15g** located directly above the needle **11a** at the tip of the syringe **11** (see Steps **S22-0** to **S23** to be described later).

Next, when driving of the first driving unit **14U** is controlled under the control from the controlling section **100**, the medicine cassette **12** together with the second pedestal **14a** is moved downward from the upper position **15d** to a puncturing position, so that the needle **11a** of the syringe **11** is inserted in the port portion **17a** of the medicine container **17** positioned on the medicine extraction position **15g** (see Steps **S24** and **S25** to be described later).

After that, when the driving of the fifth driving unit **19M** is controlled under the control from the controlling section **100**, the plunger **11b** of the syringe **11** held by the first holding portion **16** is moved downward along the direction of the arrow **33**, so that the medicine is sucked from the medicine container **17** into the syringe **11** transfusing and mixing (see Steps **S26** and **S27** to be described later).

Next, when the driving of the first driving unit **14U** is controlled under the control from the controlling section **100**, the medicine cassette **12** together with the second pedestal **14a** is moved upward from the puncturing position up to the upper position **15d**, so that the needle **11a** of the syringe **11** is removed from the medicine container **17** (see Steps **S28** and **S29** to be described later).

After that, if the medicine from another medicine container **17** is further transfused into the syringe **11**, the medicine container **17** (intended medicine container) is selected by rotating the medicine cassette **12** in the rotating

11

direction **31b** under the control from the controlling section **100**, and then puncture operation and transfusion operation are performed again.

In such a manner as described above, the medicine in the medicine container **17** on the medicine cassette **12** is trans- 5 fused to and mixed in the syringe **11**.

FIG. **9** is a front view illustrating an example, in which the medicine mixing device **10** according to the first embodiment of the present invention is placed in a small space in a hospital or a dispensary or the like. In FIG. **9**, the medicine 10 mixing device **10** is disposed, for example, on the workbench **21** in the safety cabinet **20**. In the first embodiment, the operator performs the mixing operation in a limited space of the safety cabinet **20** as illustrated in FIG. **9**, in particular, in the space in proximity to the forward surface 15 **15a** and the middle position **15c** of the main body **15** in the medicine mixing device **10**.

On the forward surface of the safety cabinet **20**, an opening **20b** is provided, through which the operator's hand or the medicine container **17** can be taken in and out. 20 Taking-in and -out of the medicine to the interior of the safety cabinet **20**, or manipulation of the medicine mixing device **10** in the safety cabinet **20**, and mounting and removal of the medicine container **17** to and from the medicine cassette **12** are available utilizing this opening **20b**. 25

In the safety cabinet **20**, clean air is flown downward from an upper portion **20c** to a lower portion **20d** so that cleanliness of the interior is maintained and no interior atmosphere leaks from the safety cabinet **20**, and air is strongly taken in from an air inlet (not illustrated) provided on the 30 workbench **21** positioned in the proximity of the opening **20b**. Such an arrangement ensures cleanliness and safety of the interior of the safety cabinet **20**.

The medicine mixing device **10** may also be associated with a server in the hospital (not illustrated) to display 35 information on the medicine and medical care, information on manipulation of the medicine mixing device **10**, or the like on a monitor **22** disposed in the interior of the safety cabinet **20**.

In the first embodiment, the reason why it is possible to 40 perform medicine mixing operation in such a small work space as illustrated in FIG. **9** is because the work space required for the medicine mixing operation using the medicine mixing device **10** of the first embodiment is configured to be fitted into a limited space around the lower position 45 **15b** of the main body **15**. Therefore, the medicine mixing device **10** of the first embodiment allows operation of mixing the medicine, such as anticancer agents, which required to be operated in an enclosed space, to be safely performed, and thus is a mixing device (transfusing device) 50 suitable for setting in a small work space. The medicine mixing device **10** of the first embodiment is particularly advantageous when being used in a safety cabinet, of which opening is disposed in the proximity of a lower portion (only the area approximately directly above a workbench). The reason is that the medicine mixing device **10** of the first 55 embodiment allows all operations to be performed in the proximity of the lower position **15b** of the main body **15**.

A medicine mixing method according to the first embodiment of the present invention using the above medicine 60 mixing device **10** will now be specifically described with reference to flow charts. FIGS. **10**, **11**, and **12** are specific flow charts illustrating a medicine mixing method according to the first embodiment of the present invention, and illustrate transfusion preparatory operation, transfusion operation, 65 and transfusion end operation. Hereinafter, a description will be given along these flow charts.

12

First, in order to initiate operation of the medicine mixing device **10**, an operator depresses the delivery start button **24a** on the operation panel **24**. At this time, the operator causes the medicine cassette **12** to hold the medicine container **17** that is used for mixing, in the second holding portion **18**. More specifically, as a cassette setting step performed by the operator (preparatory operation prior to Step **S14** in FIG. **10**), the medicine container **17** is set on the medicine cassette **12** such that the plurality of the medicine 10 containers **17** are respectively held by the plurality of the second holding portions **18** in an inverted position (see FIG. **13**). At this stage, the medicine cassette **12** is disposed separately from the medicine mixing device **10**. When the delivery start button **24a** is depressed, the first pedestal **13a** 15 of the lifting unit **13** moves to the lower position **15b** of the medicine mixing device **10** and is brought into a standby state.

Next, the operator places and sets the medicine cassette **12** holding the medicine container **17** on the first pedestal **13a** 20 of the lifting unit **13** being in the standby state at the lower position **15b** of the medicine mixing device **10** (see FIG. **14**). Specifically, the operator places and sets the medicine cassette **12** on the first pedestal **13a** while fitting each of the pair of positioning pins **13d** of the first pedestal **13a** into each of the pair of position regulating holes **12d** of the medicine 25 cassette **12** to position the fixing unit **12f** on the first pedestal **13a** (see FIGS. **15** and **16**). The operator depresses the setting completion button **24b** of the operation panel **24** when the setting of the medicine cassette **12** to the first pedestal **13a** is completed. These steps are included in the medicine cassette setting step, and are the preparatory operations before Step **S14** of FIG. **10** is performed. 30

Next, when the preparatory operation is completed and the setting completion button **24b** of the operation panel **24** 35 is depressed, the transfusion preparatory operation of FIG. **10** is initiated under the control from the controlling section **100**. That is, the controlling section **100** controls the driving of the fourth driving unit **13M** of the lifting unit **13**, so that the medicine cassette **12** together with the first pedestal **13a** 40 is, as illustrated in FIGS. **1**, **5**, and **16** to **19**, lifted from the lower position **15b** up to the middle position **15c** of the main body **15** by the pair of parallel link mechanisms **13b** of the lifting unit **13** (see Step **S14** and FIGS. **16** to **19**). At this time, since the medicine cassette **12** is lifted up by the pair of parallel link mechanisms **13b** each of which includes a pair of one S-shaped member **13bS** and one L-shaped member **13bL**, the medicine cassette **12** is raised from the lower position **15b** to the middle position **15c** while maintaining the horizontal attitude thereof. In the first embodiment, in this Step **S14**, the first pedestal **13a** is raised by the 45 lifting unit **13** from the lower position **15b** up to the middle position **15c** along the forward surface **15a** of the main body **15** in an arcuate path indicated by the arrow **32** of FIG. **5**.

Next, the controlling section **100** controls operation of the 50 fourth driving unit **13M** so that the lifting-up operation of Step **S14** is continued until the lifting-up of the medicine cassette **12** to the middle position **15c** is completed (Step **S15**). That is, on the basis of the signals detected by the encoder **13Me** in the fourth driving unit **13M**, the controlling section **100** controls the driving of the motor **13Mm**, so that the fourth driving unit **13M** continues driving in Step **S14** until the lifting-up operation of the medicine cassette **12** to the middle position **15c** is completed. The processes of Steps **S14** and **S15** are included in a first step. The first step is one 65 example of a lifting-up step of lifting the medicine cassette **12** from the lower position **15b** up to the middle position **15c**.

13

Next, when the lifting-up of the medicine cassette 12 to the middle position 15c of the main body 15 is completed (YES in Step S15), as illustrated in FIGS. 5, 18, and 19, the controlling section 100 controls the driving of the first driving unit 14U, so that the second pedestal 14a waited in a standby position 15e located below the first pedestal 13a of the lifting unit 13 is raised along the arrow 35 up to the middle position 15c where the medicine cassette 12 from the standby position 15e is received (Step S16). On the basis of the signals detected by the encoder of the fourth driving unit 13M, when the controlling section 100 detects that the reloading of the medicine cassette 12 from the first pedestal 13a to the second pedestal 14a is completed in the middle position 15c, the driving of the fourth driving unit 13M is stopped. At this time, the projection 14e on the front side of the second pedestal 14a passes through the notch 13e of the first pedestal 13a, and is brought into contact with the fixing unit 12f of the medicine cassette 12, so that the fixing unit 12f is lifted up and reloaded from the first pedestal 13a. When the controlling section 100 controls the driving of the first driving unit 14U, in the case where the controlling section 100 determines that a predetermined distance of raise has not been completed and thus the reloading of the medicine cassette 12 to the second pedestal 14a has not been completed, the second pedestal 14a is further raised by the first driving unit 14U under the control from the controlling section 100 in Step S16 (see NO in Step S17, Step S16 and FIGS. 18 and 19).

Next, when the controlling section 100 determines that the reloading of the medicine cassette 12 to the second pedestal 14a has been completed by means of the predetermined distance of the raise of the second pedestal 14a (YES in Step S17), before starting mixing the medicine, the second pedestal 14a is further raised by the first driving unit 14U under the control from the controlling section 100 in the vertical direction 31a (see FIG. 1) parallel to the arrow 35 (see FIG. 5B) up to the upper position 15d which is the home position. At this time, since the medicine cassette 12 is raised together with the second pedestal 14a, the port portion 17a of the medicine container 17 is raised up to the upper position 15d (Step S18).

Next, under the control from the controlling section 100, the lifting-up operation of Step S18 is continued until the raise of the second pedestal 14a and the port portion 17a up to the upper position 15d is completed (see NO in Step S19, Step S18, and FIG. 19). Specifically, on the basis of the signals detected by the encoder of the first driving unit 14U, when the controlling section 100 detects that the raise of the second pedestal 14a and the port portion 17a up to the upper position 15d is completed, the driving of the first driving unit 14U is stopped. When the controlling section 100 determines that the second pedestal 14a has been raised up to the upper position 15d and when the controlling section 100 determines that the port portion 17a of the medicine container 17 has been disposed on the upper position 15d (Step S19, see FIG. 20), the preparatory operation the mixing operation of the medicine is completed. The processes from Steps S16 to S19 are included in a second step. The second step is a cassette delivering step, in which the medicine cassette 12 is delivered from the first pedestal 13a to the second pedestal 14a. The processes from Step S14 to Step S19 are included in the transfusion preparatory operation.

When the completion of the transfusion preparatory operation is determined in such a manner as described, under the control from the controlling section 100, the medicine mixing device 10 instructs the operator to mount the first holding portion 16 on the main body 15 by means, for

14

example, of lighting up a lamp. In response to the instruction, the operator mounts the first holding portion 16 that holds the syringe 11 on the forward surface 15a of the main body 15. By virtue of this mounting, the coupling portion 16c of the first holding portion 16 is coupled to the driving pin 19a, thereby allowing the plunger 11b to move integrally with the driving pin 19a.

Next, when the mounting of the first holding portion 16 is completed and when the operator depresses the mounting completion button 24c of the operation panel 24, the medicine mixing device 10 initiates the transfusion operation of the FIG. 11 under the control from the controlling section 100. That is, the controlling section 100 controls the driving of the second driving unit 14R to rotate the medicine cassette 12 in forward and reverse direction with respect to the rotating direction 31b. By rotating in such a manner as described, the medicine container 17 subjected to sucking or discharging operation (intended medicine container) can be selected and disposed on the medicine extraction position 15g located directly above the needle 11a at the tip of the syringe 11 (Step S22 of the FIG. 11). Here, the selection of the medicine container 17 is determined on the basis of information on a prescription obtained, for example, from a server in the hospital (not illustrated), or information inputted by the operator (see Step S22-0 of FIG. 11, i.e., the step one step before Step S22 of FIG. 11). Here, the controlling section 100 controls the driving of the second driving unit 14R to move the medicine container 17 by rotating the medicine cassette 12 in the rotating direction 31b until the selection of the intended medicine container 17 is completed (NO in Step S23, Step S22). For example, when the types and internal capacities of all medicine containers 17 set on the medicine cassette 12 are stored beforehand in a storage section 101, appropriate medicine is selected from the storage section 101 on the basis of information on the prescription or information inputted by the operator, then the difference between the position of the medicine container 17 containing the medicine and the position opposing the needle 11a of the syringe 11 (medicine extraction position 15g) is calculated by an arithmetic operation section 102, and the amount of the rotation of the medicine cassette 12 may be controlled by driving the second driving unit 14R on the basis of the calculated result. The processes from Steps S21 to S23 are included in a fifth step. The fifth step is one example of a medicine-container selecting step, in which the intended medicine container is selected, and the fifth step is performed at at least one of before and after the third step, and before the fourth step, which will be described later.

Next, when the selection and placement of the medicine container 17 subjected to sucking or discharging operation is completed (YES in Step S23), the first driving unit 14U moves the medicine cassette 12 together with the second pedestal 14a downward in the vertical direction 31a from the upper position 15d to cause the needle 11a to puncture the port portion 17a of the medicine container 17 positioned in the medicine extraction position 15g (Step S24). Here, the controlling section 100 controls the driving of the first driving unit 14U to move the medicine cassette 12 downward in the vertical direction 31a until the puncture of the needle 11a into the intended medicine container 17 is completed (NO in Step S25, Step S24). That is, on the basis of signals detected by the encoder 14Ue in the first driving unit 14U, the controlling section 100 controls the driving of the motor 14Um, so that the controlling section 100 continues controlling the driving of the first driving unit 14U in Step S24 until the puncture of the needle 11a into the intended medicine container 17 positioned from the upper

15

position **15d** to the medicine extraction position **15g** is completed (in other words, until a predetermined distance of the downward movement of the medicine cassette **12** is completed). The processes from Steps **S24** and **S25** are included in a third step. The third step is a cassette moving-down step, in which the medicine cassette **12** is moved downward for inserting the needle **11a** of the syringe **11** into the medicine container **17**.

Next, the controlling section **100** determines that the needle **11a** is punctured into the port portion **17a** of the medicine container **17** subjected to sucking or discharging operation that is positioned in the medicine extraction position **15g** (YES in Step **S25**). When the puncture is determined, the controlling section **100** controls the driving of the fifth driving unit **19M** to initiate either one of the following operations: sucking the medicine from the medicine container **17** subjected to sucking operation to the syringe **11** by virtue of downward movement of the plunger **11b**, or discharging the medicine from the syringe **11** to the medicine container **17** subjected to discharging operation by virtue of upward movement of the plunger **11b** (Step **S26**). Here, the controlling section **100** controls the driving of the fifth driving unit **19M** to continue sucking or discharging the medicine until the predetermined amount of medicine is fully sucked to or discharged from the syringe **11** (NO in Step **S27**, Step **S26**). As a specific example, the case where the medicine is sucked from the vial bottle **17b** or the like to the syringe **11**, or the case where the medicine is discharged from the syringe **11** to the infusion bag **17c** or the like is considered. In this case, first, in the medicine mixing device **10**, the controlling section **100** controls the driving of the second driving unit **14R** to drive and rotate the medicine cassette **12**, and then, as illustrated in FIG. **5**, the medicine container **17** to be used for mixing or transfusing is disposed on the medicine extraction position **15g** located directly above the needle **11a** of the syringe **11**. After that, the controlling section **100** controls the driving of the first driving unit **14U** to move the medicine cassette **12** downward along the arrow **35** so that the needle **11a** at the tip of the syringe **11** held by the first holding portion **16** is inserted into the port portion **17a** of the medicine container **17**. When the needle **11a** is inserted into the medicine container **17**, the controlling section **100** controls the driving of the fifth driving unit **19M** to move the plunger **11b** of the syringe **11** downward along the arrow **33**, so that the predetermined amount of the medicine is sucked from the vial bottle **17b** or the like to the syringe **11** (or the medicine is discharged from the syringe **11** to the infusion bag **17c** or the like). Herein, description is given using the vial bottle **17b** or the infusion bag **17c**, which is used at higher frequencies mixing a plurality of medicines, as the medicine container **17**.

When the controlling section **100** determines that the predetermined amount of medicine is fully sucked to or discharged from the syringe **11** (YES in Step **S27**), the controlling section **100** controls the driving of the first driving unit **14U** to move the medicine cassette **12** up to the upper position **15d** (NO in Step **S29**, Step **S28**). After the controlling section **100** determines that the medicine cassette **12** has been moved up to the upper position **15d** (YES in Step **S29**), the controlling section **100** appropriately controls the driving of the second driving unit **14R**, the first driving unit **14U**, and the fifth driving unit **19M** to continuously repeat the operations of Steps **S22** to **S29** for all the intended medicines which are subjected to mixing operation (Step **S30**). In other words, in Step **S30**, if the mixing of all the intended medicine containers **17** has not been completed (NO in Step **S30** of the FIG. **11**), then return to Step **S22** to

16

repeat the operations of Steps **S22** to **S29**. In the case where sucking or discharging of intended medicine in another medicine container **17** is performed, under the control from the controlling section **100**, the first driving unit **14U** moves the medicine cassette **12** up to the upper position **15d** to remove the needle **11a** from the medicine container **17**, then the second driving unit **14R** rotates the medicine cassette **12** in forward and reverse direction with respect to the rotating direction **31b** to dispose the another medicine container **17** on the syringe **11**. After the first driving unit **14U** is driven to move the medicine cassette **12** downward to insert the needle **11a** into the medicine container **17**, the fifth driving unit **19M** drives the plunger **11b** of the syringe **11** to perform the sucking or discharging of the predetermined amount of another intended medicine. The processes from Step **S22** to this Step **S30** are included in the transfusion operation.

Here, the operator may visually determine (check) whether or not the predetermined amount of the medicine has been fully sucked to or discharged from the syringe **11** in Step **S27**. In the case of visual check by the operator, upon completion of Step **S27**, the operation of the medicine mixing device **10** is temporarily suspended, and based on whether or not a visual check by the operator is necessary, the operator, for example, instructs the controlling section **100** to perform fine adjustments to the amount of sucking or the amount of discharging.

It should be noted that during the processes from Step **S22** to Step **S29**, the medicine contained in the medicine container **17** may be stirred and dissolved in such a manner that under the control from the controlling section **100**, the first driving unit **14U** or the second driving unit **14R** drives the medicine cassette **12** in the vertical direction **31a** or in the rotating direction **31b**. As described above, by stirring and dissolving the medicine during the mixing operation of the medicine, the medicine in the medicine containers **17** can be efficiently mixed in a short time.

When mixing operation for all the intended medicine containers **17** is completed (YES in Step **S30** of FIG. **11**), by the control from the controlling section **100**, the medicine mixing device **10** instructs the operator to remove the first holding portion **16** from the main body **15** by means, for example, of lighting up the lamp (preparatory operation prior to Step **S35** of FIG. **12**). When the removal of the first holding portion **16** from the main body **15** by the operator is completed, the operator depresses the removal completion button **24d** of the operation panel **24** (preparatory operation prior to Step **S35** of FIG. **12**).

When the removal completion button **24d** is depressed, the transfusion end operation in FIG. **12** is initiated by the control from the controlling section **100**. That is, the controlling section **100** controls the driving of the first driving unit **14U** to move the medicine cassette **12** from the upper position **15d** down to the middle position **15c** (Step **S35** of FIG. **12**). Here, the second pedestal **14a** keeps moving downward until the downward movement of the second pedestal **14a** to the middle position **15c** where the medicine cassette **12** can be delivered to the first pedestal **13a**, and the release (disengagement) of the medicine cassette **12** from the second pedestal **14a** are determined (NO in Step **S36**, Step **S35**). The processes of Steps **S35** and **S36** are included in a sixth step. The sixth step is a cassette releasing step, in which the medicine cassette **12** is released from the second pedestal **14a**.

When the completion of the delivery and the release of the medicine cassette **12** is determined (YES in Step **S36**), the controlling section **100** controls the driving of the fourth driving unit **13M** so that the first pedestal **13a** lifts the

17

medicine cassette **12** downward from the position in proximity to the middle position **15c** of the main body **15** to the lower position **15b** (Step **S40**). Here, the lifting unit **13** includes the pair of parallel link mechanisms **13b**, and thus is capable of lifting down the medicine cassette **12**, while maintaining the horizontal attitude of the medicine cassette **12**. This process of Step **S40** is a cassette lifting-down step, which is one example of a seventh step. The processes from Step **S35** to this Step **S40** are included in the transfusion end operation. The operator subsequently removes the medicine cassette **12** from the first pedestal **13a** of the lifting unit **13**, and depresses the operation completion button **24f**.

Next, when the operation completion button **24f** is depressed, the lifting unit **13** moves the first pedestal **13a** of the lifting unit **13** up to the position in proximity to the middle position **15c**. When the raise of the first pedestal **13a** up to the middle position **15c** is completed, a series of medicine mixing operation is ended.

It should be noted that the step of attaching the first holding portion **16** and Steps **S22** and **S23** of selecting the medicine container **17**, are the steps performed as needed, and thus may be omitted when deemed unnecessary.

Also, a return operation to the standby position **15e** of the second pedestal **14a** may be inserted after YES in Step **S36**. In this case, the controlling section **100** controls the driving of the first driving unit **14U** to move the second pedestal **14a** downward to the standby position **15e** (Step **S37**). The operation is continued until the downward movement of the second pedestal **14a** to the standby position **15e** is completed (NO in Step **S38**, Step **S37**), and when the completion of the downward movement of the second pedestal **14a** to the standby position **15e** is determined (YES in Step **S38**), the operator depresses the dispensing button **24e** of the operation panel **24** instructing the dispensing of the medicine cassette **12** (Step **S39**). At this time, depressing the dispensing button **24e** may lead to Step **S40**.

It should be noted that here, such steps as the preparatory operation step before Step **S14**, the step of attaching the first holding portion **16** to the main body **15** after Step **S19**, and the step of removing the first holding portion **16** from the main body **15** before Step **S35** are performed manually by the operator, and other steps (such as the steps in FIGS. **10** to **12**) are automatically operated by the medicine mixing device **10**.

The medicine mixing device **10** of the first embodiment having such a configuration as described above provides a safe handling of a plurality of medicines, and also allows operators to efficiently perform medicine mixing and transfusing operation in a limited work space. Further, the medicine mixing device **10** of the first embodiment has the characteristic shaped parallel link mechanisms **13b**, by which the medicine mixing device **10** of the first embodiment can be compact, yet allowing operators to easily handle a plurality of medicines only at hand. Therefore, the medicine mixing device **10** of the first embodiment is particularly advantageous when mixing operation is performed at a limited space in a hospital, or the like.

It should be noted that in the first embodiment, the medicine cassette **12** and the first holding portion **16** are configured to be detachable from the main body **15**, which facilitates cleaning, maintenance, and replacement of the medicine cassette **12** or the first holding portion **16**.

Further, the second holding portion **18** may have a centering retention mechanism, in such a manner that the recesses **18b** on each opposing face of the pair of the fixing plate **18a** is formed in a V-valley shape, and a pair of the recesses **18b** holds the cylindrical-shaped port portions **17a**

18

and **17d** therebetween, such that the center of the port portions **17a** and **17d** automatically coincides with the center position of the pair of the recesses **18b** formed between the pair of the fixing plates **18a**. This configuration ensures that the position of the second holding portion **18** can be adjusted with the position of the tip of the needle **11a** of the syringe **11**, thereby providing a well-defined insertion of the needle tip of the syringe **11** into the center of the port portion **17a** of the medicine container **17**.

As regards vertical driving mechanism, it is not limited to the first driving unit **14**, in which the medicine container **17** vertically moves with respect to the fixed syringe **11**, and instead, a mechanism may also be employed, in which the syringe **11** moves vertically with respect to the fixed medicine container **17**. Such a mechanism may include a ball screw that rotates in forward and reverse direction by the rotation of a motor, and a nut member that moves up and down with being threadably engaged with the ball screw, and by fixing the syringe **11** to the nut member, the syringe **11** can be vertically moved by the rotation of the motor in forward and reverse direction.

By properly combining the arbitrary embodiment (s) or modification(s) of the aforementioned various embodiments and modifications, the effects possessed by the embodiment (s) or modification(s) can be produced.

Although the present invention has been fully described in connection with the preferable embodiments thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications are apparent to those skilled in the art. Such changes and modifications are to be understood as included within the scope of the present invention as defined by the appended claims unless they depart therefrom.

INDUSTRIAL APPLICABILITY

The medicine transfusion apparatus and the medicine transfusion method according to the present invention are capable of being set or operated in a limited space, capable of efficiently transfusing a medicine, and thus are advantageous in transfusing operation of a medicine performed by nurses and pharmacists in hospitals.

The invention claimed is:

1. A medicine transfusion apparatus transfusing a medicine between a medicine container and a syringe by the syringe, the medicine transfusion apparatus comprising:
 - a medicine cassette that holds the medicine container;
 - a lifting unit that moves the medicine cassette upward and downward between a middle position on an upper portion and a lower position of a main body along an arcuate path while maintaining a horizontal attitude of the medicine cassette using a pair of parallel link mechanisms;
 - a first holding portion that is capable of holding the syringe and is detachably mounted to the main body;
 - a first driving unit that relatively moves the medicine cassette and the first holding portion so that a needle of the syringe held by the first holding portion is inserted into the medicine container; and
 - a second driving unit that drives a plunger of the syringe to transfuse the medicine between the syringe and the medicine container.
2. The medicine transfusion apparatus according to claim 1, wherein
 - each of the pair of parallel link mechanisms comprises an L-shaped link and an S-shaped link, one end of each of the links is coupled to the main body, and an other end

19

- of each of the links is coupled to a first pedestal of the lifting unit holding the medicine cassette.
3. The medicine transfusion apparatus according to claim 2, wherein
- in the parallel link mechanism, the L-shaped link is disposed vertically below the S-shaped link in the lower position.
4. The medicine transfusion apparatus according to claim 3, wherein
- in the parallel link mechanism, a line connecting between portions each being coupled to the main body and to the first pedestal at both ends of the L-shaped link, and a line connecting between portions each being coupled to the main body and to the first pedestal at both ends of the S-shaped link are parallel to each other in the lower position.
5. The medicine transfusion apparatus according to claim 4, wherein
- in the parallel link mechanism, a line connecting between portions each being coupled to the main body and to the first pedestal at the both ends of the L-shaped link, and a line connecting between portions each being coupled to the main body and to the first pedestal at the both ends of the S-shaped link are parallel to each other in the middle position.
6. The medicine transfusion apparatus according to claim 1, wherein
- the lifting unit moves the medicine cassette upward and downward between the middle position and the lower position along a forward surface of the main body and along the arcuate path by a rotational movement of the pair of parallel link mechanisms.
7. The medicine transfusion apparatus according to claim 1, further comprising a first driving unit that drives the medicine cassette in a vertical direction or in a rotating direction in a plane that intersects the vertical direction, wherein
- in the first driving unit, the medicine cassette reloaded from the first pedestal of the lifting unit to a second pedestal of the first driving unit in the middle position is driven in the vertical direction or in the rotating direction, so that the medicine container held by the medicine cassette is positioned at a medicine extraction position opposing the needle of the syringe held by the first holding portion.
8. The medicine transfusion apparatus according to claim 7, wherein
- the medicine cassette includes an arc-shaped member, and has a structure, in which a plurality of the medicine containers are capable of being disposed in a circumferential direction.

20

9. The medicine transfusion apparatus according to claim 1, wherein
- the medicine cassette has a second holding portion that holds a port portion of the medicine container, and comprises a centering retention mechanism that makes a center of the port portion correspond to a position of the needle of the syringe.
10. The medicine transfusion apparatus according to claim 1, wherein
- the medicine cassette and the first holding portion are adapted to be detachable from the main body.
11. A medicine transfusion method comprising:
- a first step of moving a medicine cassette holding a medicine container upward from a lower position of a main body to a middle position on an upper portion of the main body along an arcuate path while maintaining a horizontal attitude of the medicine cassette by a lifting unit utilizing a pair of parallel link mechanisms;
- a second step of reloading the medicine cassette from a first pedestal of the lifting unit to a second pedestal of a first driving unit in the middle position after the first step;
- a third step of inserting a needle of a syringe held by a first holding portion into the medicine container held by the medicine cassette after the second step; and
- a fourth step of driving a plunger of the syringe to transfuse a medicine between the syringe and the medicine container after the third step.
12. The medicine transfusion method according to claim 11, wherein
- the lifting unit moves the medicine cassette upward between the middle position and the lower position along a forward surface of the main body and along the arcuate path by a rotational movement of the pair of parallel link mechanisms in the first step.
13. The medicine transfusion method according to claim 11, further comprising
- a fifth step of selecting a medicine container performing a transfusion operation, among a plurality of the medicine containers held by the medicine cassette, the fifth step being performed at at least one of before and after the third step, and before the fourth step.
14. The medicine transfusion method according to claim 11, wherein
- the medicine cassette is driven in a vertical direction or in a rotating direction to stir and dissolve the medicine in the medicine container after the fourth step.

* * * * *